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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

Institute of British Foundrymen.

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Secretary, E. J. Griffiths, 20, Fisher Street, Swansea.

Forthcoming Events.

NOVEMBER 11.

Institute of Metals (Scottish Local Section):—Ordinary meeting at Glasgow. "Some Difficulties in Aluminium Alloy Founding and Some Remedies," Paper by George Mortimer.

NOVEMBER 12.

Institute of Metals (North-East Coast Local Section):—Ordinary meeting at Newcastle-upon-Tyne. "Age-Hardening in Alloys," Paper by Robert Hay, B.Sc.

NOVEMBER 13.

Institute of Metals (Swansea Local Section):—Ordinary meeting at Swansea. "The Effect of Some Impurities in Copper," Paper by W. E. Prytherch, M.Sc.

Institute of Metals (Birmingham Local Section):—Open discussion on "Rolling."

NOVEMBER 14.

Institute of Metals (London Local Section):—Ordinary meeting in London. "Mineral Flotation," Paper by Livingstone Sulman.

Institution of Welding Engineers:—Ordinary meeting at Caxton Hall. "The Manufacture and Standardisation of Eye-Protective Glasses," Paper by Dr. W. M. Hampton, B.Sc.

Institute of British Foundrymen.

NOVEMBER 8.

Birmingham, Coventry and West Midlands Branch:—Visit to Foundry of Morris Motors, Limited, Coventry. Lecture on "Magnesium Alloy Castings," by E. Player.

NOVEMBER 9.

Wales and Monmouth Branch:—Ordinary meeting at Cardiff. "Making Iron in Primitive Times," Paper by Prof. Read.

NOVEMBER 12.

Lancashire Branch (Burnley Section):—Ordinary meeting at Burnley. "A Comprehensive Paper," Paper by E. Flower.

A Hardy Annual.

There is more than a little food for thought on the part of the foundry industry in the present position of the Cast Iron Research Association, consideration of which is rendered pertinent by the fact that its Annual Meeting was held yesterday, the President, Major-General Sir Philip A. M. Nash, K.C.M.G., presiding. The Association has now completed its eighth year of work, and its strongly entrenched position must be the cause of considerable satisfaction to the Council and officers of the Association, as it is the cause of much appreciation on the part of all who have the progress of our industry at heart. The Association has indubitably succeeded in winning the confidence both of the industry for whose ultimate benefit it was founded and the Government Department without whose financial support its career could neither have been launched nor continued. The first of these points is illustrated by the steady rise in its subscription income, and still more significantly by the fact that its membership lies increasingly among the larger firms, the average subscription having increased over 20 per cent. in the past four years. These large firms, having plentiful equipment and resources of their own, would be the first to dispense with the Association's services were they not convinced that those services were of real value. The second of these points is demonstrated by the fact that the Advisory Council of the Department of Scientific and Industrial Research has arranged for a continuance of grant on extremely generous terms. These terms need not be given in detail here, as they are elsewhere available, but if the fullest measure of advantage is to be taken of them the Association must receive the whole-hearted support of the industry.

A particularly interesting feature of the year's work is the inauguration of a development department to undertake the intermediate work that is necessary if the results of scientific investigations are to be of the fullest use to the industry. Such work has, of course, always been a prominent part of the Association's activities, but its recognition in this way is of special significance. We have in these columns repeatedly pointed out the vital need that exists for adequate liaison between science and industry. The scientist criticises the industrialist because he will not put his results into practice; the industrialist criticises the scientist because those results are all too often presented in a form in which they are practically unintelligible to him. Some means of bridging this gap is obviously needed, and the Association seems to have found such a means. It establishes and maintains an industrial point of view by constant personal visits of its officers to the works of members and prospective members, and by the attention it devotes to members' problems. It derives a scientific point of view from the fact that it actually inaugurates and prosecutes scientific research, and works in close contact with scientific institutions throughout the country. And by its development work, whether recognised as such or not, it links the two together in a way that is invaluable to both.

While those who have come into contact with the Association are unanimous in their appreciation of it, there are others slow of conviction. This may be unfortunate for the Association, whose value increases with the degree of its universality, but it is doubly unfortunate for the individuals concerned, who are thus depriving themselves of such proven advantages.

Discarded Inquiries.

There is something fundamentally defective with the present system of marketing grey-iron castings, which is attributable to the fact that, whilst all foundries are limited in their scope, their representatives are almost forced, for the sake of their commercial contacts, to pass along a large number of inquiries which they know must be turned down as being unsuitable. One London agent states that after "seeding" his inquiries by 30 per cent., his foundry, which has up to a 1-ton range, declines another 25 per cent.

This reflects on the industry as a whole, as indicating an inability to give a live service. There exist certain foundries which specialise in speed of delivery, so that an odd casting or set of castings may enable a rush or breakdown job to be expeditiously carried through. They do not want any repetition work, as it would detract from their elasticity. A second type regards the receipt of a one- or two-off job as a nuisance, and constituting an order which merely clogs the wheels of their production. The position could be enlarged upon almost *ad infinitum*. Taking it as axiomatic that foundry profits are augmented by the increased output of castings of a character for which the plant was designed, then there are several means for its consummation. Primarily, there is the possibility of district joint selling agencies, which would seed inquiries just as every representative does, but the discard would receive attention instead of being birth-strangled. A second solution is a series of horizontal trusts of a new type—schemes carefully designed to assure the buyer of the widest possible range. Such schemes would allow of better and more effective representation; the institution of the finest technical control; the recognition of the real value of the

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small jobbing foundry; an ideal training ground for future technicians, and a presentation to the public of what the foundry industry really implies. A third suggestion is the creation of "Casting Exchanges" on the lines of the Birmingham quarterly meeting, whereat those "discarded" inquiries could be readily assimilated by other sections of the industry. It should be remembered that no buyer can circulate an inquiry to the 3,000 ironfoundries of Great Britain, nor even a fraction of that number. He can only be guided by advertisement and general knowledge of the industry.

In grey iron alone there is the problem of bringing together some 50,000 buyers and 3,000 sellers. The whole of the larger foundries seem to favour the elimination of the smallest, because of their price-cutting propensities, yet we feel that a logical examination of the question would show that under a rationalised system of co-ordinated operation, that they could be kept fully and profitably employed by the one- and two-off jobs which are now being made in larger concerns. Herein, with skilled help, much experimental work could be developed, whilst variety of output would attract and retain the really skilled operative for the lasting benefit of the industry in general.

Autogenous Welding of Copper.

The oxy-acetylene welding torch has rendered the welding of copper objects a practicable process, but considerable practice and care are necessary to obtain good results. Particular attention must be given to the preparation of the metal for welding, and the edges of the joint must be bevelled in order to weld through the whole thickness of the metal, except in the case of thicknesses below 2 mm. Up to 5 mm. thickness not much bevelling is required, but over that thickness the angle of the joint should be about 60 deg. A carefully-cleaned joint is necessary, and the cleaning can be done with file, scraper, or emery, and even when hydrochloric acid or nitric acid are employed, previous scraping is desirable.

The high heat-conductivity of copper necessitates the use of a considerably larger burner than would be used on iron and steel of equal thicknesses, though care must be taken to avoid melting the metal through an excess of heat. Pure copper may be used as a welding rod, but phosphor-bronze is in most cases more convenient and preferable. The phosphorus present in the rod is removed practically entirely in the welding. The effect of the phosphorus is to bring the melting point of the rod below that of the copper, and this assists in obtaining a good joint without overheating the metal to be welded. Since, however, the presence of phosphorus reduces the ductility of the copper, the phosphorus content of the rod should be kept within such limits that it is removed during the process. Without some deoxidising element in the welding rod, the joint tends to become oxidised and its strength lowered. The surface of the metal, also, should be covered with a mixture of potassium phosphate and potassium carbonate to a thickness of 1½ mm. The heat of the flame melts this mixture and forms a glaze over the copper, which prevents oxidation. Another flux consists of sodium chloride, sodium borate, and boric acid. This should be used sparingly, by dipping into it the end of the welding rod.

The flame of the burner should be regulated so that it is neither oxidising nor reducing in character, and the white rays of the flame should not be allowed to play on the metal. It has been found beneficial to hammer well the welded seam and its immediate surroundings and then to heat the copper up to 500 or 600 deg. C., after which it is quenched in cold water, or otherwise quickly cooled.

Buchanan Medal Awarded.

Mr. John Hird, of the Birmingham Junior Section, who has been awarded the Buchanan Medal, was born at Shipley, Yorks, on November 25, 1907. He was educated at Deacon's School, Peterborough, and Reading Grammar School. At the works of Messrs. Guest, Keen & Nettlefolds, Cwmbran, South Wales, he had experience in the drawing office, tool room, machine shops and foundry. Choosing foundry work as a career, Mr. Hird completed his training with Messrs. Belliss & Morcom and the Birmingham Aluminium Casting Company. In August last he was appointed assistant to the foundry manager of Messrs. R. A. Lister & Company, Dursley, Glos. He has been an active member of the Birmingham Junior Branch.

Mr. John Hird.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Large Light Alloy Castings.

To the Editor of The Foundry Trade Journal.

Sir,

Our attention has been drawn to a letter in your issue of September 12 describing and illustrating a large crankcase casting of 268 lbs. weight in modified aluminium-silicon alloy, and suggesting that this is the largest casting of its kind produced in any British foundry. Without entering into details, we would assure your correspondent that this is not the case.

It never occurred to us to claim a record in this connection, but we are producing a marine crankcase here, in the same alloy, of greater weight and greater linear dimensions. Apart from crankcases, our production in modified aluminium silicon alloy includes castings up to more than three times the weight mentioned by your correspondent as a regular commercial proposition.—Yours, etc.,

For William Mills, Limited,
J. F. Paige,
Deputy Manager.

Grove Street, Birmingham.

Random Shots.

Now that winter is upon us at last—and I suppose even the summer of 1929 could hardly be expected to last for ever—the winter sessions of the various branches of the I.B.F. are in full swing. And in countless homes all over the British Isles countless husbands are saying to countless wives: "I.B.F. meeting to-night, my dear. Don't bother to wait up for me!" And countless wives are replying: "I call it a shame, having to go to a meeting on a Saturday night!"

* * *

It would be interesting, as a matter of fact, to know just exactly what is the general experience in the matter—whether Saturday meetings really are better attended than meetings held on a Thursday or any other night of the week. It could legitimately be argued that if a man is keen enough on the meeting or interested enough in the subject that is to be discussed he would come at any time, while if the object is to convert the heathen, so to speak, nothing short of cheery chats in the dinner hour are likely to do the trick. Your Englishman has a great reputation for working hard and working wholeheartedly when he *is* at work, but he has no less a reputation for liking to forget all about it afterwards. It is hard enough to get the boys to technical classes and night schools; how much more courageous is he who would get their fathers to Saturday evening meetings! And when you consider the rival attractions that offer themselves in these degenerate days—football, wireless, the cheap car, the talkies, the modern girl—is it really anything to wonder at? However, perhaps the real reason why some of us like Saturday meetings is conveyed in my first paragraph. . . . Got it?

* * *

By the time you read this I shall have attended—unless I fall a victim to the seasonable cold or have a difference of opinion with my car (or anyone else's, for that matter)—the annual meeting and luncheon of the Cast Iron Research Association. Oh, yes, I know the Editor can give you details of an event at twenty-four hours' notice—but, then, Editors can work miracles, even to the extent of giving you those same details in advance once in a way! Not being the Editor, however, I shall have to tell you about it next week, but I have already heard that quite a number of interesting and distinguished people are likely to attend—no, I mean are likely to have attended—no, probably have already attended—I can't manage the tenses! What I am trying to convey is that on Wednesday, November 6, which is in the future to me as I write and will be in the past to you as you read, a number of interesting and distinguished persons will partake of lunch on the occasion of, etc., etc. . . !

* * *

And, talking of lunches, it is an easy transition to dinners, and a still easier one from dinners to after-dinner speeches. And in this connection I am told that nowadays the proverb, "Laugh and Grow Fat," merely means that the fellow who tells the best yarns gets asked to all the best dinners. Well, I mean to say, just have a look at some of them!

Marksman.

How Industry might be Developed at Home and Abroad.

Under the auspices of the Falkirk, Grangemouth and East Stirlingshire Publicity and Development Association, MR. HAROLD M. FORD, secretary of the Clyde Navigation Trust, addressed a meeting of business men in Falkirk last week. Mr. Ford, in the course of his address, spoke of his recent mission to Australia and New Zealand, which he said had two objects. The first was to invite the attention of the primary producing interests of the two Dominions to the size and value of the Northern markets of Great Britain and how these markets could be cultivated by them. The other object was to bring to their notice the basic industries and manufactures of Scotland with the view of building up a reciprocal trade between the two Dominions and the Mother Country. The wonderful British Empire Exhibition at Wembley told them more plainly than anything else what the British Empire stood for. He was disappointed that a lot of the valuable work done at Wembley was not followed up by the marketing of produce, both in Australia and New Zealand. As a result of the work of the Empire Marketing Board there had grown up a desire to be more closely allied with the Dominions and to support them in their struggles in opening up and in developing their countries and industries as never before. The British shopkeeper was being looked to by the Dominions to play his part by stocking more British goods. The more British goods sold the better the opportunities for the settlers in the Dominions. The two Dominions of Australia and New Zealand were more than anxious to deal with them, but in many instances they were very much annoyed with some of their procedure and antiquated methods, preventing them supporting their markets as they should do. Many English bridge-building and girder firms were well known in Australia and New Zealand. Scottish firms were hardly known, and it occurred to him that there was something radically wrong when Scottish firms were not better represented out there. Personal contact was necessary in building up Dominion trade, and in this respect many Scottish firms had shown a lack of initiative and foresight.

He found that fencing wire and bars, agricultural machinery and all sorts of iron requirements were being catered for by America, Germany and English firms. The Germans were supplying the two Dominions with enamelled baths and enamelled ware in general. This was because not that there was a desire to deal with them but because the Germans offered to send their goods insured from the time they left Germany. Scottish and English firms insisted on sending out at the other man's risk. While they sat at home grumbling about bad trade, appointing chambers of commerce, setting up committees and complaining about taxation, he would suggest that some of the money wasted in that direction could be more profitably spent by emulating the Americans and going out to secure orders. There was room for considerable development of Scottish Trade in the Australian market. Concluding, he said that the inauguration of their Association in Falkirk was a step forward.

In the course of a discussion at the conclusion of the address, MR. GEORGE SCOTLAND, a director of the Falkirk Iron Company, Limited, said it was strange that they should lose trade on the question of insurance. The real explanation was a much bigger question. British bath makers just now were offering baths to New Zealand and Australia at rates which did not cover their factory costs, and even at these figures the Germans were undercutting them by 33⅓ per cent. Australia, in addition, was making a big percentage of her own baths, and they threw up tariff walls over which they could not get.

MR. FORD said that they accepted what Mr. Scotland had said, but he contended that the Australian would buy a British bath, even if it was a little higher in price, simply because it was a British bath. Mr. Scotland pointed out that they had many unemployed men in that particular branch of industry. The question of German prices was serious. The Germans were landing 6,000 baths per month into this country.

BAILIE LOGAN, in proposing a vote of thanks, said that in the housing schemes in Glasgow German baths were to be found. This was unfortunate, but they were there. He hoped the feelings in the Dominions for the Mother Country would be more and more circulated at home, for it would prove of great advantage to the town and community of Falkirk and district. Perhaps the Association might get in touch with housing authorities at home and draw attention to the fact that British goods were available for British houses.

Coal-Dust in the Foundry.

The Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen opened the session with a meeting on Saturday, October 26, at the Chamber of Commerce, Birmingham, at which Mr. B. Hird (Newport) repeated the lecture which he gave in June at the International Foundrymen's Congress in London on "Coal-Dust as applied to Moulding Sand." Mr. E. H. Tyson, the Branch-President, was in the chair. The occasion was taken to present the Buchanan Medal, won by Mr. John Hird, of the Birmingham Junior Section, a duty which was gracefully discharged by the late Mr. Buchanan's daughter, Mrs. T. H. Gameson.

In proposing a vote of thanks to Mrs. Gameson, MR. F. J. COOK recalled Mr. Buchanan's pioneer work in connection with the Institute, and mentioned that there was present another of the "originals" besides himself in the person of Mr. J. Ellis.

The proposition was heartily endorsed by the meeting, and MRS. GAMESON briefly acknowledged the compliment.

In inviting Mr. Hird to deliver his address, the CHAIRMAN commented on the coincidence that father and son were playing a prominent part in the proceedings.

MR. ELLIS proposed a vote of thanks to Mr. Hird, describing his work as very original.

MR. T. H. TURNER, in seconding, asked whether 30 per cent. of coal-dust was the economic maximum or the absolute maximum. It appeared, he said, that the notion that coal-dust made the facing sand more porous—a theory advanced in text-books—was wrong. In coal-dust they were adding a material which gave the best results if it was volatile. That was to say, it was producing a quantity of gas instead of allowing the passage of gas, which was theoretically assumed to be in the metal, and ought to get away. Mr. Hird's statement that better results were obtained when a mould cover was used suggested that the function of the dust was to produce gas, and that gas under pressure was useful. Could they couple with that extraction of heat from the metal? Sand was a good insulator, and in order that the metal might solidify in the mould the heat must be carried away from the sand. There was not enough oxygen present to produce much combustion of the dust. It might, therefore, be taken that the coking action, which was endothermic, was going to extract heat from the metal that they wanted to solidify. Was it not possible that Mr. Hird's results were due to the pressure of gas and to the coking action actually producing a slight chill, giving the clean skin that was desired, after which the solidification of the rest of the metal behind could take place normally?

MR. HIRD, referring to the percentage of coal-dust, said every man must work out his own salvation. He had had too much experience to be drawn into giving any mixture and saying, "If you use that all will be satisfactory." (Laughter.)

MR. F. J. COOK said while, of course, they did not use coal-dust with dry-sand work, he wondered whether the addition of some fine coal-dust would be of use mixed with wet blacking.

MR. J. G. PEARCE said the Paper represented only the beginning of the work, and if any other foundryman would like to achieve immortality by carrying it further, the Cast Iron Research Association would be delighted to co-operate. They had the help of the suppliers of the materials, who would provide any quantity required in any grist that was called for. Of the two questions that appeared to agitate the meeting, he regarded the question of the amount of coal-dust to be used, its function, its degree of fineness to be far more important than pock-marking, ratching and so on. The view taken by the Research Association in the past with regard to coal-dust had been, roughly, this: "Never use a coal-dust which is coarser than the sand you have at your disposal, and preferably have it about the same degree of fineness as the sand; and, with regard to the quantity, use as little as will produce the surface effect that your castings demand." On the basis of trial it was easy to find out the precise quantity that suited customers. He should add that the more coal-dust they introduced the worse became the permeability and strength. It was bad in every respect except in the production of a good surface. Mr. Hird had confined his work entirely to red sand. Red sand did not behave like black sand, and he (Mr. Pearce) thought they ought to try black sand as well.

The vote of thanks was heartily accorded.

Newark Foundry's Progress.

So rapid has been the progress made by Messrs. Ransome & Marles, of Newark, since the end of the war that it was stated at the annual meeting that the present rate of manufacture was equivalent to producing a year's pre-war output in half a day. MR. V. S. WOODS, chairman of the company, said the 1929 balance-sheet was the most favourable submitted since the formation of the company. The whole of the first debenture, which five years ago amounted to £80,000, had now been repaid, and the second debenture had been reduced to £26,000. The result of the year's trading showed a profit of £41,179, the greatest in the history of the company.

At present, he said, there were indications of a busy year, and he refuted the statement that the company was likely to be taken over by a competitive concern. He paid tribute to the excellence of the staff and employees. Mr. Scaife, who had been works manager for ten years, had resigned to take up a position abroad, and his place had been filled by Mr. Richardson, who had been with the company since its formation.

COL. HIGGS regretted that the great progress that had been made was, unfortunately, countered to a large extent by an extraordinary, and, he hoped, artificial, level of prices. They were also faced with the strongest possibility of their productive duties—the McKenna duties—being removed at the next Budget. It was obvious to the manufacturers and employers that a very difficult question would arise if a protective duty was put on or taken off frequently.

Mr. J. Mason, the retiring director, was re-elected.

MR. H. WINTERTON and Mr. G. H. Roberts, both well known in the industry, have been elected members of the local municipal authorities at Milngavie and Coventry respectively.

Institute of British Foundrymen.

LONDON JUNIOR SECTION.

The first meeting of the session of the London Junior Section was held on October 25 at the offices of The Foundry Trade Journal, at which there was a good attendance.

The meeting opened with an address by the newly-elected Chairman, Mr. H. R. E. Slater. Mr. Slater thanked the members for the honour accorded him. The aims of the Junior Section, he believed, were to give young men an opportunity of learning to form their own views and expressing them in a proper manner, so that later on they might be able to take an active part in the meetings of the Senior Section.

During the past session they had had a good variety of Papers dealing with different branches of founding. Although it was perhaps difficult for them all to understand each Paper, they derived value from them, as it made them try to understand the part played by other sections of the industry. He was pleased to be supported by Miss Pittuck, as Vice-Chairman, and Mr. Ellis, as Hon. Secretary, and was looking forward to a successful session. In conclusion, he wished to express a hearty welcome to all present. A vote of thanks was accorded to Mr. Slater.

Foundry Practice.

An interesting talk on Foundry Practice was then given by Mr. H. G. Summers.

The lecturer touched upon the work of the moulder, the coremaker and the furnaceman. He went carefully into the methods of moulding with green sand and dry sand, pointing out that discretion must be used in the ramming of the sand, size and shape of the casting being taken into consideration; good venting was also essential.

Strict attention should be paid to runners. In his (the lecturer's) opinion, more wasters were caused through bad runners than from any other cause. They should be designed to fill the mould quickly and smoothly. The two main factors were the basin and downgate, which should be of ample proportions in order to keep a good head of metal during pouring. The sizes of downgates and ingates were governed by the type of casting, and it was advisable, where there were thin and thick sections, to cut the ingates into the thin ones. The area of the ingates should not exceed that of the downgate.

The use of risers on moulds was examined, the lecturer describing the different types used. He said that it was a mistaken idea amongst moulders that risers kept the mould free from dirt.

Cores played a very important part in the making of a casting, and great care had to be taken in the marking of them. He thought he was justified in saying that no two foundries made their core-sands alike; there was, in fact, a great need for standardisation along these lines. As in the making of a mould, special care must be taken with the venting of cores; in large cores it was advisable to make a series of channels and fill with ashes. There was a great deal to be said in favour of sea-sand cores, which required very little ramming and were practically self-venting, although it was advisable to insert a few channels to aid drying.

The lecturer went on to describe the type of cupola he advocated. He pointed out that in charging the furnace it was important to measure the coke and weigh the iron. The blast pressure should be just sufficient to reach the centre of the cupolas, and to melt from 18 to 22 in. above the tuyeres, and the coke charges should correspond. He considered it was good practice to melt 10 lbs. of iron to 1 lb. of coke, and emphasised the importance of keeping the charges uniform.

The lecture aroused a long discussion, and Mr. Summers was heartily thanked for his interesting Paper.

Book Reviews.

Hochwertiger Grauguss (High-Strength Grey Cast Iron), by Prof. Dr. Ing. Eugen Piwowarsky. Published by Verlag von Julius Springer, 23 to 24, Linkstrasse, Berlin. Pages 336, with Indexes. Price 42 mks.

The investigations into cast iron during recent years, carried out by a band of investigators in Germany of whom Dr. Piwowarsky may be regarded as the leader, have been followed with very close interest in this country. This increases intensely the importance of this book in the eyes of foundrymen, metallurgical students and all those interested in the progress of the metallurgy of cast iron, both in this country and throughout the world. The value of the co-ordinated expression of the views of the leaders of scientific investigation in the ordinary course of scientific development cannot be too highly estimated. In the special case of the metallurgy of the complex material cast iron, such co-ordinated views of the leaders of thought are of untold value to all those whose interests are bound up in this material. The fact that "Hochwertiger Grauguss" presents the co-ordinated views of a leader of investigation in Germany assures for this book the position of a landmark in the development of the metallurgy of cast iron.

To the research worker the very complexity of cast iron as a material, in its constitution and behaviour, offers an irresistible attraction. In spite of this fascination, the ultimate possibility that the clearer and fuller understanding obtainable from investigation may prove of commercial value, remains as a reward for the labours of the investigator. The title "Hochwertiger Grauguss" rendered into English as "High-Strength Grey Cast Iron" is happily chosen, stressing, as it does, an object underlying the desire for a clearer and more definite comprehension of cast iron, its constitution and properties. It is obvious that the progress of such understanding must benefit to a large degree by the concurrent advances in other branches of science, particularly the branches of physical chemistry and physical metallurgy. The author has appreciated this and has wisely devoted considerable space to the presentation of the physical metallurgical principles, with special reference to cast iron. The constitutional diagram, the phase rule and the process of solidification and crystallisation are dealt with in the opening section. As an instance of the author's perception of the special needs of cast iron from this point of view, mention may be made of the prominence given to the construction and interpretation of the more complex ternary constitutional diagrams. The iron-carbon diagram, the constitution of the iron-carbon-silicon alloys and the whole phenomena of graphitisation is exhaustively treated in the following sections. The author has drawn from his own important researches and those of other prominent German investigators in elaborating both this and the study of the influence of superheating and casting temperature in the section which follows. The influence of sulphur, phosphorus, manganese and dissolved gases is treated in various sections, following from a refreshingly modern standpoint. Heat-treatment, volume changes and the important properties of cast iron, including magnetic and electrical properties and corrosion, are followed by a very full treatment of the melting of cast iron. In this latter section the principles of cupola operation, the influence of pre-heating the air blast and the injection of water into the cupola receive ample consideration in the light of the important German investigations on these subjects. The section on melting cast iron is concluded by a short treatment on the air furnace and electric furnace, reference being made to the Brackelsberg rotary powdered-fuel-fired design.

The remaining sections of the book are devoted to the consideration of the principles involved in the production of high-quality grey irons. This aspect of the subject is dealt with in sections dealing with the properties of the matrix constituents, in which the Perlit process receives its share of attention; the refining of the graphite structure, in which section is treated the Thyssen Emmel process; the influence of special elements, in which nickel and chromium claim a fair share of attention.

The book is very carefully compiled and well written; full and ample references are made to the work of other investigators, not only in Germany but in many other countries. We notice that the work of the leading British metallurgists, Turner, Hatfield, Hurst, Fletcher and others has been fully acknowledged, and the Research Reports of the British Cast Iron Research Association have been drawn upon. We notice one or two slight errors in the spelling of English proper names. Fletcher in several instances has been rendered "Fletscher," Pitman as "Pittman" and Sir Robt. Hadfield and Dr. W. H. Hatfield have been confused in the index of authors. These are slight and understandable and do not detract in any way from the value of the work. Printed on good paper, with excellent illustrations and well indexed, the book represents a contribution to the literature on cast iron of the foremost importance. We express the hope that means will be found to offer an English translation at an early date to enable a wider field of foundrymen to participate in this important work.

Pipe and Tube Bending and Jointing, by Stanley P. Marks, M.S.I.A. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price 6s. net.

The large mass of information presented throughout the 160 pages of this book is couched in simple terms in order that the beginner, as well as the more experienced worker, in the plumbing, gas-fitting, pipe-fitting, coppersmith, engineering cycle-making, boat and aircraft building and other trades may benefit from it. It deals with lead, copper, brass, aluminium, zinc, tin, iron and steel, electric conduit and ebonite tubing, while a chapter headed "Miscellaneous Useful Matter" fully bears out its description. Additional value is derived from the number of excellent photographs and drawings with which this very useful book is illustrated. Although the coating of steel tubing with zinc and with nickel is mentioned, there is no reference to chromium plating, nor is "cellulose" included under the heading of "Enamelling." Apart from these omissions, the book is very thorough and should prove exceedingly useful.

Estimating, by T. H. Hargrave. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price 7s. 6d. net.

This manual for draughtsmen, cost clerks, foremen, works managers and engineering students covers a wide field in its 120 pages. The information concerns the engineering industry in all its branches, one chapter being devoted to foundry estimates. The section on "Overhead Charges" will be found particularly useful, especially by those whose ideas on the subject, and they are many, are rather vague. When overheads can run into as much as 30 per cent. of the works expenditure, it is obvious that the importance of a correct allocation is great, and, it is pointed out, a good deal of the variation in prices submitted by different firms arises from varying methods of estimating the overhead charges. The author divides the overheads into two classes:—(1) Workshop expenses, including provision of power, buildings, supervision, maintenance and depreciation, interest on capital and unclassified labour; (2) establishment charges, including sales expense, packing and delivery, general expenses, such as office salaries, fees and royalties. A number of specimen estimates are given, based on actual works experience.

German Foundry Research Work.

Professor Piwowarsky, on the occasion of a recent visit by the Belgian Foundrymen's Technical Association to the Aachen Technical College, took the opportunity of outlining the position of the research work being carried out under his supervision. These researches have primarily been oriented to the amelioration of the quality of cast iron. The work dealing with the superheating of cast iron and its influence upon the shape of graphite was well known.

The growth of cast iron had also been studied, especially the different elements which produce and influence growth. It has been shown that a fine segregation of graphite brought about by superheating diminishes growth. Thus with two irons of the same analysis, one of which has been cast at an ordinary temperature and the other superheated, the growth of the latter is less than that of the first. These results agree with those of F. Wüst.

Researches on degasified cast irons proved that growth diminishes with the percentage of gas present, and it has been found that the rôle of gases in cast iron is of the greatest importance. This growth *in vacuo* is not so great as in air. It is now known that the harmful influence of silicon upon growth is reduced by the substitution of part of the silicon content by nickel.

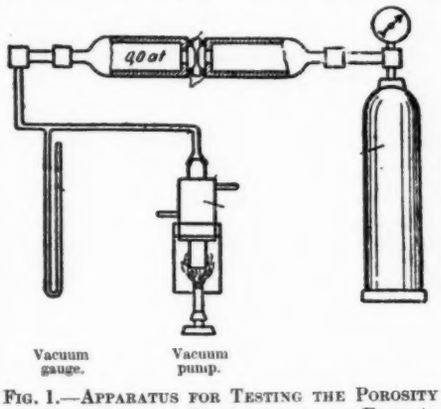


Fig. 1.—Apparatus for Testing the Porosity of Cast Iron. (Piwowarsky and Esser.)

In addition to the mechanical properties of cast irons, the corrosion by acids and alkalies had also been studied. It had been proved that the addition of nickel had a decidedly favourable influence in resisting concentrated alkalies.

Work on the machinability of cast iron was not yet completed. On the other hand, it had been found that cast iron was not so porous a material as had been thought. It was not the microscopical porosity but rather the macroscopical defects, such as pulls, blow-holes and tears, etc., which were the cause of the permeability of cast irons.

By subjecting a plaque of cast iron carried in a special apparatus, to hydrogen pressure at 150 atmospheres, whilst the other side of the plaque is a complete cavuum, a gas diffusion has been observed only when the thickness of the plaque does not exceed that of the graphite flakes. In this way, there has been found a gas diffusion for Luxemburg iron, when the test-plaque was 0.8 mm. thick; for special grey cast iron, the thickness was only 0.5 to 0.6 mm. Gas diffusion was impossible for a plaque of 1 mm. thickness. The lay-out for the diffusion or porosity test is shown in Fig. 1.

Further, researches had been made on the influence of oxygen on cast iron. Molten iron at elevated temperatures absorbed hardly any oxygen. Oxygen plays rather the part of a reducing agent by diminishing the percentages of silicon, manganese and carbon. Even by blowing air or oxygen in the ladle before casting, oxygen has only been observed entering into the composition of the test-pieces when cast at low temperature.

Concerning malleable iron, the Institute was working upon the influence of nickel and chrome, and, at the same time, means for reducing the annealing time.

Chill casting has not yet been fully studied; nevertheless, the influence of nickel and chrome in the manufacture of rolls, etc., has been controlled.

Work on non-ferrous metals was commenced recently, and, for the moment, studies were being made to ameliorate the properties of aluminium castings by treating them with chlorine.

The interest attached to steel castings at present was especially due to their heat-resisting qualities, resulting from the influence of the alloying elements, manganese, nickel, chrome and molybdenum.

Besides these purely metallurgical problems, the working and conduct of the cupola had been carefully studied. One of the results established shows that the temperature of the iron and the quantity melted per hour increases with the quantity of air blown in the cupola. Excess of coke is of greater disadvantage than an insufficiency of air. By diminishing the coke charge, it has been established that the thermal efficiency of the cupola becomes almost independent of the quantity of air, but the efficiency naturally diminishes with the decrease of air.

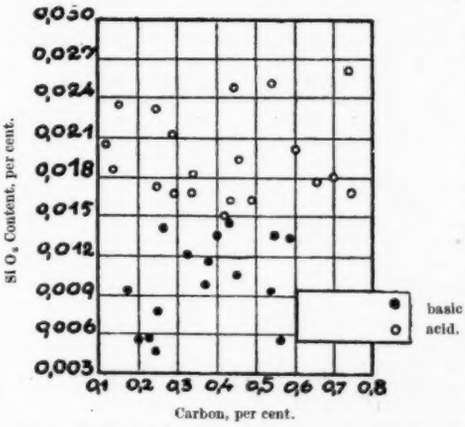


Fig. 2.—SiO_2 Content of Basic and Acid Steels.

The question of carbon pick-up in the cupola has been studied in a cupola constructed by the Institute, and it has been found that this reaction occurs below the tuyeres, that is to say, in the hearth.

Tests have been made on heating the blast and the injection of water in the cupola, both in the laboratories and in practice.

Concerning steel castings, it has been proved that the percentage of silica found by residual analysis in acid steel is always greater than in the basic process, as is shown in Fig. 2. This is due to the fact that in the basic process, in spite of a minute deoxidation, the non-metallic products emanating from the deoxidation are always rich in SiO_2, and, therefore, are very viscous. They cannot coagulate and, in consequence, do not rise to the surface of the bath. Dr. Nipper is engaged upon extensive researches into foundry sands.

Collaboration with practice has always been one of the Institute's principal objects, and at this moment there are a great number of researches being carried out on a practical scale, which were initiated and directed by the Institute. For example, tests are being carried out at the "Vereinigte Stahlwerke" on high-pressure pipes of nickel, chrome, then the manufacture of rolls from special iron.

The different properties of foundry irons having the same chemical compositions were being investigated through the initiative of the "Verein Deutscher Eisengiessereien." Two tons of different foundry irons and hematites, which have already arrived at the Institute, will be melted in the cupola under the same conditions. The mechanical, physical and technical properties of this iron will be studied from all angles.

In addition to these more-or-less practical problems, there are naturally physical chemistry and equilibrium diagrams, deoxidation, desulphurisation and dephosphorisation, etc., which are deeply interesting. A research dealing with the influence of silicon, phosphorus and nickel on the equilibrium lines of the ternary diagram, was nearing completion.

Lancashire Junior Foundrymen in Session.

The Junior Section of the Lancashire Branch of the I.B.F. began the Session 1929-30 with a meeting held on October 26 at the Manchester College of Technology. Mr. R. A. Miles presided.

The "John Wilkinson" Medal was presented to Mr. F. L. Topham, of Bolton, who also received a book prize. Mr. B. Haigh, of Manchester, who gained the second place, was also given a book prize. The Buchanan Memorial Medal was presented to Mr. E. Garside, of Manchester.

In his presidential address, Mr. Miles said he was afraid the number of things, apart from their trade, in which young foundrymen were interested prevented many from attending the meetings of the Junior Section, but he hoped the enthusiasm which created it would revive and increase. The very useful information derived from the Papers presented ought to attract, but the social aspect was also of great importance. In an organisation of this kind there were better opportunities for knowing one another than would be the case if the meetings were simply in the form of classes, and a man could not know too many people in his own or in allied kinds of trade or business. He (Mr. Miles) had never known a member of the Institution to refuse information to an inquiring friend.

In these days the conditions in the foundries were much better for the juniors than they were formerly. Opportunities offered themselves to young men with keen observation powers, and no junior should be afraid of approaching his foreman or manager with any suggestion which might improve methods or conditions. His advice to them was, never be afraid of your own abilities. The foundry trade required men who were prepared to risk putting their ideas into practice and proving or disproving them. There was plenty of scope for young men all the way up the ladder in British foundries.

He asked the juniors to make every effort to strengthen and extend the Section; they had greater opportunities in that respect than many members of the Senior Section. Any suggestions for improvement in organisation should be put into writing and would receive sympathetic attention.

Mr. A. L. Key (Vice-President) gave an address, illustrated by lantern slides, upon "Large Castings by Jolt-Ramming Methods." He described how the machines operated and gave an account of how several jobs had been carried out.

Imported Machinery Belting.

The Standing Committee appointed by the Board of Trade will hold an Inquiry on November 18 and 19 as to whether imported machinery belting (including conveyor and elevator bands) other than belting of metal should bear an indication of origin.

Production of Iron and Steel in Japan.

In the course of an article reviewing the Japanese iron and steel industry, Mr. J. H. Ehlers (Acting Commercial Attaché, Tokyo, of the U.S. Department of Commerce) points out that, as Japan has been, and is even now, one of the principal markets of the world for steel products, the expansion of the industry of that country is of especial interest to the industries of the United States, Great Britain and Germany, and to a lesser extent to those of Belgium and Luxemburg, France and Sweden, all of which now sell iron and steel in Japan. Japan is also worthy of consideration as a producer of steel and steel products quite apart from its importance as a consuming market. In 1928, and for several years past, Japan has ranked tenth among the countries of the world in volume of steel produced, production having risen from 255,000 metric tons in 1913 to an estimated total of 1,680,000 tons in 1928.

This development, a truly remarkable performance in view of the many factors tending to restrict it, could scarcely have taken place except under the peculiar economic system prevailing in Japan, a system under which the Government is in a position to foster the expansion of industries despite natural or economic disadvantages. The profits returned by the industry have scarcely been such as to warrant the expansion which has taken place over the last eight years, yet over this period production has virtually doubled—figures for 1920 indicate an output of 804,133 tons of steel ingots in that year against an estimated output of 1,680,000 tons in 1928.

The steel industry has never recovered a satisfactory position since the panic of 1920, although now, in 1929, prospects seem brighter than they have since the end of the war. In 1925 eight important steel companies made an average profit of 2½ per cent. of their paid-up capital. In 1926 private steel companies, in which Yen 230,000,000 is said to be invested, showed a profit of only Yen 9,000,000. Only two companies—the Kawasaki Dockyard Company and the Osaka Iron Works—showed profits of 5 per cent., and both these companies were compelled to go through a radical readjustment programme in 1927.

Pig-Iron Production.

Japanese pig-iron production takes place in three areas—Japan proper, Chosen (Korea) and Manchuria. Japan proper has three iron-smelting districts, the Kyushu district, the district embracing the northern part of the main island (Honshu), and southern Hokkaido; in addition, one furnace is being operated in the Tokyo district. The 1926 production was distributed as follows:—Kyushu, 58 per cent.; Manchuria, 18 per cent.; northern Japan and Hokkaido, 14 per cent.; Chosen, 10 per cent. There is a distinct market for pig-iron in Japan, and this will unquestionably increase as the industrialisation of the country progresses.

The production of pig-iron in Japan has shown a continuous increase since the establishment of the industry on a modern basis. Output has increased from a total of 237,775 tons in 1912 to 884,233 tons for Japan proper in 1927. The combined production of Japan and Chosen passed the 1,000,000-ton mark for the first time in 1927, while production in the whole area, including Manchuria, was 1,254,504 tons.

The production of pig-iron and ferro-alloys in Japan is detailed in Table I. The importance of Chosen and Manchuria is obvious from an inspection of the figures. Nearly all of this production comes to Japan with the exception of small amounts retained in the producing areas for foundry purposes. The great increase in the Manchurian production during the past few years is of especial interest. The constantly increasing production in this area would indicate that the technical problems involved in the utilisation of low-grade ores were being solved, although the figures do not necessarily indicate that this production is being conducted on a profit-making basis as yet, for the South Manchuria Railway, the company engaged in this production, is a semi-governmental institution, and has resources sufficient for carrying on experimental work over a period of years. The fact remains, however, that it is becoming a dependable and important source of pig-iron supply for Japan.

Table I.—*Production of Pig-Iron and Ferro-Alloys in Japan (metric tons).*

Year.	Japan.	Chosen.	Manchuria.	Ferro-alloys.	Total.
1912	237,755	—	—	1,413	239,168
1913	240,363	—	—	2,313	242,676
1914	300,221	—	—	1,505	301,726
1915	317,748	—	29,909	2,879	350,536
1916	388,691	—	49,022	3,201	440,914
1917	450,642	—	38,610	12,150	501,402
1918	582,758	42,698	45,712	23,670	694,838
1919	595,518	78,384	106,082	17,091	797,075
1920	521,036	84,118	116,037	8,839	730,030
1921	472,725	83,010	93,951	7,575	657,261
1922	550,845	83,179	59,842	8,465	702,331
1923	559,698	99,933	97,849	11,053	808,533
1924	585,930	99,795	134,376	12,475	832,576
1925	685,178	99,160	136,685	10,933	931,956
1926	809,624	115,036	198,143	12,208	1,135,011
1927	884,233	126,132	244,139	13,000	1,267,504
1928	—	—	—	—	1,507,764*

* Plus a certain quantity (not indicated) of ferro-alloys.

Blast-Furnace Equipment.

In general, the blast-furnace equipment of Japan is by no means up to date. Although pig-iron is often produced cheaply in many countries in somewhat antiquated blast furnaces, and, while the stacks themselves may not be of great importance, except as to size, the auxiliary equipment determines the economy of the plant. In many Japanese plants, however, this is not of recent type, and in the interests of economical production might well be modernised or replaced.

Table II shows the location of this blast-furnace equipment. Contemplated changes in equipment involve the erection of two furnaces of 500 tons at Yawata, one of 500 tons at Anshan, the installation of a new 200-ton furnace by the Kamaishi Mining Company, the possible addition of some capacity by the Asano Iron Works at Tsurumi, and the construction of two 170-ton furnaces by the Japan Steel Company's plant at Wanishi, Hokkaido. The Asano interests are considering the erection of a 350-ton furnace at Osaka. No pig-iron is at present being produced in that district.

The rated capacity of the Japanese blast-furnace plant is 1,500,000 tons per year. The contemplated equipment would bring the productive capacity to over 2,500,000 tons theoretically, but actually to about 2,000,000 tons, since some of the contemplated furnaces would replace existing units which would then be closed down.

Table II.—*Japanese Blast Furnaces.*

Name.	Daily capacity in metric tons.											Total furnaces.	Annual capacity.
	300	270	250	230	200	150	130	120	100	60	25*		
Japan Proper.													
Yawata Steel Works	—	2	—	1	3	—	—	—	—	—	—	6	465,800
Kamaishi Mining Co.	—	—	—	—	2	—	—	—	—	1	1	4	164,900
Nippon Steel Works (Wanishi)	—	—	—	—	—	—	—	3	1	—	—	4	156,400
Toyo Iron Manufacturing Co.	1	—	—	—	—	—	1	—	—	—	—	2	153,000
Asano Shipbuilding Co. (Tsurumi)	—	—	—	—	—	—	1	—	—	—	—	1	51,000
Nippon Steel Pipe Co.	—	—	—	—	—	—	—	—	—	—	3	3	23,500
Asano Kokura Steel Works	—	—	—	—	—	—	—	—	—	—	2	2	13,600
Okura Mining Co.	—	—	—	—	—	—	—	—	—	—	2	2	13,600
Sennin Iron Manufacturing Co.	—	—	—	—	—	—	—	—	—	—	2	2	9,180
Kobe Steel Works	—	—	—	—	—	—	—	—	—	—	1	1	6,800
Yosuki Seikojo	—	—	—	—	—	—	—	—	—	—	1	1	5,100
Shiribeshi Iron Manufacturing Co.	—	—	—	—	—	—	—	—	—	—	1	1	6,800
Kuji Steel Works	—	—	—	—	—	—	—	—	—	—	1	1	3,400
Chosen.													
Mitsubishi (Kenjiho) Iron Works	—	—	—	—	—	2	—	—	—	—	—	2	120,000
Manchuria.													
Honkeiko Iron Works (Penhsihu)	—	—	—	—	—	2	—	—	—	—	2	4	102,000
Anshan Steel Works	—	—	2	—	—	—	—	—	—	—	—	2	280,000
Total	1	2	2	1	5	4	2	3	1	1	16	38	1,575,380

Note.—These data were taken from the records of the Mining Bureau of the Japanese Department of Commerce and Industry. Cupolas for remelting iron are included.

* These are 25 tons and under. Practically all of the furnaces (cupolas) are for remelting.

Japan proper has 15 blast furnaces of a daily capacity of 100 tons or over, one being rated at 300 tons and eight between 200 and 300 tons. The equipment of Chosen consists of two furnaces of 130 tons capacity, while Manchuria has two furnaces of 300 tons, as well as two of 150 tons daily capacity.

Birmingham I.B.F. Branch Visit.

On October 9 about 45 members of the Birmingham, Coventry and West Midlands Branch paid a visit to the Dudley Foundry Company, Limited, Brierley Hill, and the Stourbridge Glazed Brick & Fireclay Company, Limited, Dudley. The party were met at the foundry by Mr. W. E. Harper (director and secretary), and an interesting hour was spent studying the various foundry operations. Although not a large foundry, this concern produces castings from a few ounces up to 5 tons, and a large variety of sanitary castings were seen in the course of production. The foundry also has two cupolas operating on the Poumay system. The party then proceeded to Dudley to the glazed-brick works, and here a most interesting set of operations in the manufacture of glazed bricks and fireclay sanitary fittings were inspected. This works has a very high reputation throughout the country, and its products are of the highest quality. Gas-fired kilns of the producer type are in use, and many of the operations in the casting and moulding of fireclay products bore a striking resemblance to foundry work. Tea was kindly provided by the Stourbridge Glazed Brick & Fireclay Company, the chair being taken by Mr. W. E. Harper, of the Dudley Foundry, supported by Mr. F. E. Clark and Mr. C. Fenn, of the Fireclay Company. The thanks of the members was tendered by the Branch-President (Mr. E. H. Tyson) and Mr. D. H. Wood (Past-President).

Some Factors in Solidification.*

By Dr. S. W. Smith, A.R.S.M., F.I.C.

A proper appreciation of the factors which are involved in the solidification of metals and alloys is essential to anyone who is engaged in preparing them for the purposes for which they may be required in industrial work.

The metallurgist, after all, is the person who is expected to understand the constitution of the material which he is handling, and to understand it in a more intimate and fundamental sense than the engineer who is concerned more particularly with its behaviour under particular conditions.

To understand material in this intimate sense the metallurgist must consider, as far as possible, what happens to it, or what may happen to it, during the process of solidification from the molten state. In the simple case of pure metals solidifying in the crucible or container in which they have been melted, there are certain fundamental properties peculiar to each metal—their melting points, forms of crystallisation, and so on. There are other factors, too, which may have important results in regard to the subsequent behaviour of the metals when in use.

Solidification of Quiescent Metals.

If metallurgists could only attain their objects without the necessity for *disturbing* the molten metal by the operations of transfer from one receptacle to another, many of their troubles would be minimised if they did not disappear altogether. Although steps have been taken to minimise some of the ill-effects of transfer we are still a long way from eliminating many of the worst features of this operation.

A simple case of quiescent solidification is that of a molten globule, which one can observe without inconvenience. Such a globule can be observed during the stages of the well-known operation of cupellation, an operation which has been practised for centuries in the determination of the gold and silver contents of so-called bullion—used in its broadest sense. This operation consists of melting together a weighed sample of the metal and an excess proportion of lead—the lead, for convenience, being in the form of foil or sheet, in which the sample is wrapped. The melting of this composite packet is then effected on the surface of a small cup-shaped vessel or cupel of semi-porous material, such as bone-ash or other refractory substance, which has been previously placed in a suitable muffle furnace.

When the lead packet is put into the furnace and exposed to a gentle current of air, it melts almost immediately, and a dark scum forms on the surface. As the temperature rises the surface clears owing to the fusion of the oxide of lead, which "wets" the surface of the cupel and runs or is drawn into it much in the same way as water passes into a lump of sugar. The operation proceeds without appreciable change until the greater part of the lead has been removed. Then a change occurs. The surface of the metal, which so far has been quite flat right up to the cup-shaped surface of the cupel, now begins to draw away, at the edges, in an effort to form a rounded or hemispherical surface in accordance with the well-known property of all liquids to assume a spheroidal form when the conditions admit of it. The forces which have come into play at this stage are relatively so great that unless the conditions of temperature, smoothness of the surface of the cupel and the composition of the molten metal are favourable, there is a great danger that the continuity of the fluid metal may be broken and that small beads detached from the main mass may be left high and dry above the level of the falling tide. There exists, then, a conflict of forces which may affect the continuity of the metal. Assuming for the moment that continuity has been preserved, what then has happened at this stage before all the lead has been removed? Clearly, forces have come into play, which are the manifestations of the forces of cohesion in liquids generally which are displayed by a tension on the surface layers.

Up to this stage, these forces, although of course acting, have not *manifested* themselves, and the surface of the metal has apparently been in close contact with the refractory material of the cupel. Actually, however, it has never really been in intimate contact; that is to say, it has never actually "wetted" the cupel in the way the molten film of lead oxide has wetted it, and has been absorbed by it.

The tension in the surface of the metal has, from the start, been sufficient to withstand any tendency to break it down or to allow the metal as a whole to pass into the pores of the cupel, to do which, of course, it would have to subdivide itself into tiny globules.

Such a break-down in the cohesion of the metal, followed by a complete absorption by the cupel, can, however, be brought about by suitably arranging the composition of the metal.

Fig. 1.—Three Stages in the Operation of Cupellation.

Thus, if in addition to gold and silver the small lead bath had contained a certain minimum proportion of an element such as tellurium, which has a low surface-tension, then the cohesion of the liquid would have been so weakened that the surface forces which tend to hold the globule in a spheroidal form and prevent it from subdivision, would break down altogether and be overcome by the wetting effect of the lead oxide, with the result that the metal, as a whole, would spread over the surface of the cupel and then pass downwards through the pores.

Under favourable conditions, however, and in the absence of such constituents as tellurium of low surface-tension, the cohesion is preserved, and oxidation of the lead proceeds with an increasing tendency towards a spheroidal form until all visible films have disappeared and the surface of the globule presents a specular appearance.

In this simple operation, therefore, we see the evidence of forces of cohesion which are sufficient to prevent subdivision in the earlier stages, and are sufficiently strong in the later stages to give a spheroidal form to the globule and to enable it to overcome the adhesion exerted by the film of oxide which is in actual wetting contact both with the metal and with the cupel.

The part thus played by the film of molten oxide as a sort of "nexus" between the metal and the material of the cupel is important, because it can be shown that a globule of gold, silver, tellurium and lead, which will be *completely* absorbed by a "*wet*" cupel, will remain molten and spherical on a "*dry*" cupel, *i.e.*, on one from which oxygen is excluded.

The varying degrees of cohesion thus exhibited in the molten condition will, of course, be manifest in the globules after solidification, those which exhibited strong cohesion will be quite malleable, while those which lacked cohesion will be quite brittle.

The interest which is being shown in this question was abundantly demonstrated by the contributions made to a recent symposium arranged by the Faraday Society on "Cohesion and Related Problems." Prof. Porter summed up the situation by saying that "The subject of molecular forces is a somewhat elusive one; many attempts have been made to derive a knowledge of it from experimental results, and yet there is no certain knowledge concerning it at the present day."

Behaviour of Cooling Globule.

As the temperature falls several phenomena associated with the solidification of molten metals may be readily and conveniently observed:—

(1) The metal may cool to the neighbourhood of its solidification temperature when suddenly the surface may be broken by the liberation of a considerable volume of gases which have hitherto been held in solution or occluded in the metal. The escape of these gases may cause the projection of a spray of molten globules from the surface, leaving the solid button in a spongy or porous condition.

(2) By taking suitable precautions to prevent this occurrence, one may observe phenomena of a totally different character depending upon a totally different property. The surface of the molten metal may remain perfectly smooth and unbroken, and may cool until it is duller in appearance than the cupel upon which it rests. Suddenly, however, it will "flash" with a "brightness" which is in strong contrast to the colour of the surrounding cupel. The metal has *supercooled* or *surfused* below the temperature at which its latent heat is normally liberated—its freezing point. The sudden liberation of this latent heat as the metal solidifies has been sufficient to raise its temperature momentarily above that of the cupel. The true explanation of this was first given by Van Riemsdijk, of the Utrecht Mint, in 1880.

(3) A further observation may be made at this stage. As the surface skin solidifies a depression will form in the centre of the button, showing that the contraction of the metal during solidification has pulled the surface skin inwards in an effort to fill the void caused by contraction during solidification.

(4) If an effort is made to remove the button by forceps while it is still hot, it may, under certain circumstances, burst and display a fine scattered crystalline structure, thus showing that its cohesion is diminished while hot or that it is "hot short." The same button if cooled completely would be perfectly malleable.

(5) If, instead of withdrawing the globule from the furnace while it was still molten, it had been allowed to remain and to solidify very slowly, a further observation might have been made. It would have been found that the surface, instead of being smooth, was divided up into a number of more or less polygonal areas corresponding to distinct crystal grains and that each of these areas tended to be flat and tangential to the original hemispherical surface of the molten button. Moreover, within each area there would be indications of parallel rows of crystallites, and in adjacent areas these parallel rows would run in different directions.

These, of course, are manifestations of the well-known observations from microsections that the crystallites in one grain have an orientation differing from those in adjacent grains.

Thus by slow-cooling—when large grains have time to form—the surface forces which are tending to preserve a spherical form are partially overcome by the forces which orientate the crystallites in each crystal grain, with the result that instead of a smooth hemispherical surface one finds a prismatic one with polygonal faces.

A recent Paper by Professor Bannister, presented at the Düsseldorf meeting of the Institute

* Extracted from the Chairman's Address delivered to the London Section of the Institute of Metals. Dr. Smith is the Chief Assayer to the Royal Mint.

of Metals, which is a continuation of some earlier work which he carried out in collaboration with Mr. Patchin, contains records of some very interesting observations of the influence which various elements in small quantities may have in conferring a characteristic appearance to the surfaces of solidified globules.

(6) Finally, if an effort is made to remove the button from the cupel when it is quite cold we may find that this operation requires some force, as the lower surface may be found to have adhered to the face of the cupel. As we remove the button some portion of this surface may be torn away with it. Even after brisk treatment with a stiff brush the lower surface of the button is seen to be mottled and pitted, thus showing that in contact with the cupel its surface has been broken up and moulded by adhesion as the result of the film of oxide which has been in actual wetting contact both with the metal and with the cupel.

Factors in the Solidification Process.

In this simple operation, then, we have seen the evidence of at least eight factors which may enter into the process of solidification and exert their influence on the character and properties of the solidified metal. These factors arise from:—(1) The possible oxidation of certain constituents and the question of how and to what extent they may be removed, (2) the degree of cohesion of the metal in preserving its continuity, (3) the rejection or retention of dissolved or occluded gases, (4) the surfusion or undercooling of the metal, (5) the volume changes at solidification, (6) the diminished cohesion while hot—or "hot shortness," (7) the evidence of the forces of crystallisation being restrained by or overcoming those of surface tension, and (8) the evidence of adhesion to the containing vessel or mould.

Removal of Oxidisable Constituents.

One cannot, of course, hope to remove products of oxidation in the manner described, viz., by absorption through the walls of the mould (in this case, the cupel). Any steps to be taken to prevent oxidation are usually governed by the character of the oxides which are likely to be formed and also by the ease and completeness with which any protective covering which may be used may be removed from the surface before pouring, or otherwise prevented from becoming entangled in the metal during casting and solidification.

The character of any products of oxidation which may be present is of great importance in relation to the final condition of the metal.

The ease with which they may be eliminated will depend on:—(i) Whether they are readily fusible, as in the case of PbO, (ii) whether, although infusible, they readily disentangle themselves from the molten metal, *e.g.*, ZnO or P_2O_5, (iii) whether they actually dissolve in the metal (Cu_2O), and (iv) whether they are both infusible and also tend to remain entangled in the metal (oxides of Mn).

Liberation of Gases.

Next, with regard to the liberation of dissolved or occluded gases during solidification. Their successful removal constitutes a problem to almost all branches of metallurgical production. The addition of deoxidisers may have for its object, not only the reduction of metallic oxides to the metallic state and the removal of the oxygen as a substitution product, but it may also have for its object the actual ejection of these gases. It is clear that under ideal conditions the removal of gases should be effected in the furnace or crucible, although this is not always possible. Where it is inevitable that some gases shall be liberated during actual solidification one is faced with the possibility that these may remain in the casting, either distributed more or less uniformly as pin-holes or, if the conditions are favourable, they may be induced to accumulate in some part of the casting where their effect is either less harmful or where the metal containing them can be cut off and rejected. All foundrymen know the possibilities which lie in this direction.

Other proposals have been made for eliminating gases. This is a question to which Mr. Archbutt has given close consideration. These proposals involve either the passage of a neutral gas through the molten metal or else pre-solidification of the metal and elimination by re-melting.

In all these problems one could profitably consider a little more closely those analogous occurrences which are observable more conveniently during the solidification of ordinary liquids or solutions. For instance, there is a record of some experiments which were made more than 40 years ago and published in "Nature" (February 3, 1887). They concerned the "phenomena connected with the freezing of aerated water," and the following observations were made:—(1) The upper or surface portion of a coating of ice invariably contains less included air than its under or lower portion, and this is more obvious in ice formed over shallow than over deep water. In each case there is a fairly regular gradation of entangled air, increasing from the surface downwards; (2) there is more included air (weight for weight of ice) in an entirely frozen mass than in ice from a partly frozen vessel (*i.e.*, a concentration goes on); (3) in freezing separately the water from which the first frozen coat of ice has been removed, the ice contained a much larger proportion of included air than either the surface ice or the ice obtained from entirely freezing a body of water; (4) on re-freezing water which had been frozen and thawed there was but a very slight further release of air which had been almost entirely released in the first freezing, and (5) in completely freezing a vessel of water not only does the entangled air increase in quantity downwards, but at the base of the frozen mass there is a large air cavity. These facts and experiments indicate that, in the process of freezing, the elimination of the air and gases is taking place in two ways:—(1) A part of it is extruded as bubbles of air which become entangled in the ice, and (2) a part (the greater part) is continuously surcharging the underlying water as it is progressively rejected by the freezing ice above it until, at the end, the remaining air or gas is extruded as one large bubble.

(2) seems to take precedence of (1), which would explain the comparative absence of air bubbles in ice over deep water, because there is plenty of water to take up the air.

These observations are, of course, consistent with (1) the benefits found from pre-solidification of metals or alloys, and (2) with the benefits derived from cooling cast metal from the bottom upwards.

Liquid Contraction during Solidification.

Let us examine for a moment one familiar instance or aspect of the effects of liquid contraction continuing after a part of the metal has solidified. When the upper margins of metal cast into a chill mould solidify before solidification is complete in the central and lower portions, piping will, of course, occur. [In steel practice the upper portions of the metal are sometimes kept molten by impinging gas jets on them until the lower portions have solidified, or the moulds may be filled from the bottom.] This tendency to piping may also be accentuated by adhesion of the molten metal to the sides of the mould, thus preventing the general level from falling as the metal contracts. The degree to which this may happen depends to some extent on the condition of the surfaces of the moulds, and also on the success with which mould dressings have been applied. Thus, if the metal has any tendency to "wet" the sides of the mould in the sense in which the molten lead, which we considered earlier, may "wet" the substance of the cupel by the intervention of a film of oxide, then marked adhesion may occur. If, for instance, a silica ball be filled with small pieces of a non-ferrous alloy and then heated sufficiently to melt the metal, it will, on cooling, solidify without adhesion, especially if the interior be graphitised. A small mass solidified in this way will be found to have a density approaching, if not equal to, that of worked metal—certainly the density will be higher than metal cast in the ordinary way.

In a Paper read at Düsseldorf, reference was made to the procedure of melting metal in the mould in which it is to be cast, and so avoiding the necessity for transfer from one receptacle to another. Whether we had anticipated this procedure at the Mint in point of time or not I do not know, but we did certainly make a very successful casting of pure gold in this way some time ago. The gold was melted in a silica mould of rectangular cross-section, considerably longer than that occupied by the metal when molten, so that the portion of the mould above the surface of the metal was well within the furnace. The heat supply was then shut off and the metal allowed to cool in the furnace. In order to overcome any tendency to adhesion to the mould, the mould was kept in a constant state of vibration while the metal was contracting. In this way piping was avoided, and, what was even more important to us, the operation of pouring and its attendant evils were eliminated.

Molten Metals Undergoing Transfer.

The operation of pouring, or otherwise transferring molten metals or alloys from the vessel—whether crucible or furnace—in which they have been melted to the receptacle or mould in which it is desired that they should solidify, is one of the most troublesome operations with which the metallurgist has to cope.

Successful casting is the basis of all successful metallurgical production, whether it be the tiny castings of high melting-point alloys which are so skilfully made in connection with dental work—a province of casting calling for methods peculiar to itself—or whether it be the mass production of die castings of increasingly complex designs, or the relatively enormous castings of steel billets which are required for subsequent fashioning into armaments, or other important engineering requirements.

It would be quite impossible, in the short time at our disposal, even to attempt to touch upon the various arts and devices for effecting the transfer of molten metal and for ensuring its satisfactory solidification under these varied conditions. Such an attempt would lead us to considerations of (1) suitable pouring temperatures; (2) suitable mould temperatures; (3) suitable mould dressings, and many other factors, each of which, of course, requires special consideration for specific requirements.

Here, again, analogies with the behaviour of liquids at ordinary temperatures may help one to form some conception of what may happen during this operation. As an approach to this question one cannot do better than turn back to some interesting experimental work which was carried out by Prof. A. M. Worthington in the 80's and 90's. This work was directed to the examination, visually and later on photographically, of the stages which occur during the "Splash of a Drop." By ingenious devices the splash of a drop, either of liquid into another liquid or of a solid into a liquid, was analysed visually. By illuminating the surface of a liquid momentarily by an electric spark, Worthington was able to show the precise form and configuration of the disturbance caused by the drop at precise intervals of fractions of a second.

The metallurgist may find profit in reflecting on some of the consequences which may follow if a stream of molten liquid should suffer discontinuity or splashing during the act of transfer by analogy with this experimental work,

(*Continued on page* 340.)

British Cast Iron Research Association.

EIGHTH ANNUAL REPORT FOR THE YEAR 1928-1929.

The Council has pleasure in reporting to members that the year covered by the present report, ending June 30, 1929, has been the most momentous so far experienced in the history of the Association. Measured in general activity, in income and in expenditure, the year has been a record. Furthermore, the future of the Association, both immediate and distant, has been placed on a sounder basis, largely through the sympathy and encouragement of the Advisory Council of the Department of Scientific and Industrial Research. Finally, an important change, directed towards increasing the usefulness of the Association to members, has been made in the internal organisation by the creation of the Development Department. The results of research work take a considerable time to mature, and even then a further period of development is required before these results are fully applied in industrial practice. There are, however, ample signs that the research policy pursued by the Association since 1924 is bearing fruit, and in view of the pressing nature of the problem of distributing the information and of applying it to actual foundries, the formation of a Development Department is already overdue.

The question of the standardisation of working procedure has been advanced to a marked degree by the publication during the year of recommended methods for the analysis of pig and all kinds of cast iron and various other foundry materials.

Services Rendered by the Association.

The formation of a Development Department formally recognises the third of the main services rendered by the Association to members, and in the interests of new and prospective members it is convenient at this stage to review these activities.

Information Bureau and Library.

The object of the Library and Information Bureau is to provide the staff and members of the Association with any information which they may require relating to the industry. For this purpose a very complete library of books and periodicals concerning the founding industry is maintained, in charge of a skilled librarian. Patent specifications and commercial literature are included. The collection is very highly specialised, and other information which may be required from time to time is obtained through an extensive series of contacts with other libraries and information bureaux both in this country and abroad, which have been created by the Information Bureau. Information is supplied in response both to specific and general requests, and the material in the library is always available on loan.

Research Work.

The primary work of the Association is the conduct of a number of investigations for the purpose of increasing available knowledge of the cast irons, in order to improve their quality and cheapen their production. This work is carried on, not only in the Headquarters laboratories, but at the Scottish laboratory, in the works of a number of members, and in universities and other national institutions. The range of this work is determined by the fact that the quality of cast iron in the casting is influenced very markedly by the melting procedure, and by the foundry practice employed in the process of manufacture. Hence the melting and annealing furnaces used in the industry and the auxiliary materials such as moulding and core sands, refractories and fuels, form essential parts of the research programme. In fact, notwithstanding the title of the Association, the keynote of its work lies in the art of founding, and not merely in the material cast iron. Perhaps the outstanding developments of the year have been the remarkable performance of a new type of cupola, for the design of which the Consultant, Mr. J. E. Fletcher, is responsible, and the results of investigations carried out by the Senior Metallurgist, Dr. A. L. Norbury, on heat-resisting irons and on the influence of melting conditions on the structure and properties of cast iron.

Members generally do not know that the Association has power to undertake investigations on behalf of individual members, subject to special financial arrangements. The Association, however, does not undertake to carry out routine tests that may be required in connection with ordinary production in members' works.

For convenience, however, the analyses and other tests required in connection with work in progress are centralised in various small laboratories at Headquarters. During the year the chemical laboratory conducted over five hundred analyses, involving 2,700 estimations, each in duplicate. In addition to pig, grey, malleable, and chilled irons, work was done on ores, slags, refractories, coal and coke, together with a wide range of special elements often added to cast iron. In the metallography laboratory some four hundred visual examinations were made, of which one-sixth were photographed for permanent record. In the mechanical testing laboratory some three thousand mechanical tests were made, with the necessary preparation and machining and sampling for the chemical laboratory.

Members' Inquiries.

From the beginning the Association has made a special feature of dealing with inquiries from members who are faced with problems relating to foundry work. This service has proved extremely popular, and the number of reports issued during the year under review approaches 350, therefore averaging between one and two for each working day. These inquiries cover a very wide range. They embrace matters relating to pig-iron, mixtures, melting practice, moulding practice, casting design, alloy additions, annealing and after-treatment.

They are treated as strictly confidential, and members are expected to treat replies in the same way. This work has the very great advantage of keeping the staff in extremely close touch with industrial practice, and it offers an opportunity of enabling the latest scientific knowledge at our disposal to be incorporated speedily into industrial practice. The replies are based, not only on scientific knowledge, but upon prolonged practical experience, combined with a knowledge of the particular conditions that operate at a member's works.

Letters received make it clear that this service is keenly appreciated by members, and it is, from the technical point of view, very advantageous for the officers of the Association to know when their recommendations have been successful, for such knowledge enables further advance to be made without taking too great a step at any one time. On the other hand, it is equally important that the officers of the Association should be informed when any recommendations are not as successful as they anticipate, as this may lead to the discovery of some factor which militates against the success of a recommendation known to be otherwise suitable. Recommendations to members are based on scientific principles, and do not consist in passing information on from one source to another. Each case is treated on its merits, and it may be said that no inquiry put forward resembles any other inquiry, for underneath purely superficial resemblances there are always wide variations of local conditions and practice which make it impossible for the recommendations given to one member to be suitable for another.

The Council is aware that the application of scientific results to practice involves much more than the consideration of individual difficulties or desires. The need for building up a section of the organisation able to deal with industrial applications on a more extensive scale, particularly those arising from research work in progress, has resulted in the formation of a Development Department.

Industrial Development.

It is not difficult to distinguish between the research aspect and the development aspect of work that is actually in progress, and it has been found that the latter requires a considerable amount of specialised activity. In the simplest cases many members are in a position to undertake unassisted the whole of the development that is necessary if research results are to be embodied in practice. Here it is only necessary for the results obtained to be circulated in a research report or communicated at a private meeting of members. As the application becomes more complicated, however, many members find themselves inadequately supplied with staff and laboratory facilities, and it is then necessary to supplement the publication of results by practical foundry advice. In the last resort, that of technical and large-scale improvements, even the largest members may in the future require the services of members of the staff in adapting results to practice, sometimes for considerable periods. The function of the Development Department will be to ensure that results of all these varying degrees of complication find their due and proper way into industrial application. It is to this application of scientific results through adaptation and development that members look for those improvements in quality and reduction of cost of production that must ultimately justify the Association's existence. In future, therefore, this work will be allocated to a separate department of the Association's work. It is to be known as the Industrial Development Department, in parallel with the Research Department and the Information Bureau and Library, the three sections representing the three major aims of the Association.

Standardisation.

There are other services which the Association renders, less to individual members than to the industry as a whole. As a representative technical body for the industry opportunities for such services often occur. The most important of these arises in connection with tests, testing procedure and specifications. Here it is the Association's constant effort to ensure within the industry the adoption of the best tests and methods of procedure, and to encourage those outside the industry who buy or use castings to work on a sound basis in their specifications. In view of the work done by the Association in assisting the Institute of British Foundrymen to secure the passing of the national specification for cast iron, B.E.S.A. Specification 321, 1928, the Council has viewed with considerable satisfaction the increasing adoption of this specification by users, and has noted that the principles it embodies have also found favour abroad. During the year the Association has issued a series of recommended methods for the sampling and analysis of pig, grey, malleable and chilled irons, together with methods for sampling and proximate analysis of blacking and plumbagos. It is hoped that these methods will be used for acceptance tests on raw materials and work in progress, and that discrepancies arising from differences in method will be eliminated.

Work of the Council.

The Council re-elected as its chairman Mr. H. B. Weeks, F.I.C. It is noteworthy that Mr. Weeks has never been absent from a Council meeting since the Association's inception. The Council is fortunate in having his experience and unremitting zeal at its disposal. Mr. F. J. Cook and Mr. J. T. Goodwin have also served as vice-chairmen, and have devoted much time and attention to the work. Much to the Council's regret, the serious illness of Mr. Oliver Stubbs has precluded him from taking any active part in the work of the Association.

The Council has to record with great regret the loss by death of its past vice-president, Mr. T. V. Miles, J.P., of Newton, Chambers & Company, Limited, Sheffield.

Since the close of the year under review the Research Committee has appointed a Patents Sub-Committee to deal with important questions of policy which arise out of patents taken out in connection with the work of the Association.

Meetings have been held at London, Birmingham, Falkirk and Sheffield, and the thanks of the Council are due to the Iron and Steel Institute for the occasional loan of its council room.

Work of the Research Committee.

The research programme is supervised by the Research Committee, which, during the year, has had Mr. H. B. Weeks, F.I.C., as chairman, assisted by a number of Sub-Committees for specialised investigations. The following progress has been made in the chief investigations undertaken during the year.

Heat-Resisting Cast Iron.

Some remarkable results have been obtained by Dr. Norbury, the senior metallurgist, and Mr. E. Morgan, M.Sc., on alloys which have hitherto not been supposed to possess heat-resisting properties. The composition of these alloys has been made the subject of British and various foreign patents, after which it is hoped to make full disclosure to members. In the meantime the work has been dealt with in Research Report No. 69, and the co-operation of members interested in developing these alloys will be welcomed. They have been tried sufficiently on an industrial scale to confirm laboratory results, and Prof. Sir Harold Carpenter, F.R.S., who carried out the classical work on the growth of cast iron twenty years ago, has described the results as revolutionary. Since the report referred to has been published, other advances have been made to overcome some difficulties relating to the mechanical strength of the alloys in question. Test-bars were made from a variety of mixtures and tested at temperatures from 600 deg. C. to 1,000 deg. C. by repeated heating in the presence of moist carbon dioxide. The increases in weight and volume were noted after each heating. The results have not only radically modified existing views with regard to the effect of composition on growth, but have led to a clearer conception of the nature of growth and how it is affected by the ordinary elements of composition, and by graphite.

Some heat-resisting irons of the older type to a composition recommended by the Association were utilised in low-temperature carbonisation retorts at the Greenwich station of the Fuel Research Board. It is understood that these retorts have been in service over a year, and have withstood growth and distortion to a highly satisfactory degree. For all-round suitability these irons have proved themselves to be excellent.

The Association has decided to undertake an investigation into the properties of the irons used in ingot moulds, and the support of ingot-mould makers as a whole is being sought in order to enable the required data to be furnished. This information is required primarily by the steelmakers for the purpose of studying the thermal gradients in steel ingots with a view to the production of the perfect steel ingot. This problem is being dealt with by the Heterogeneity Committee of the Iron and Steel Institute.

Cupola Practice.

The experiments referred to in the last Report at the works of the Carron Company, by kind permission of Mr. George Pate, O.B.E., where a cupola designed by the consultant has been operating, have resulted in a very marked advance, and the cupola, producing 80 to 100 tons of molten metal per day, is yielding the metal with a coke consumption of the order of 6 per cent. at a temperature of 1,400 deg. C. to 1,425 deg. C., and is pouring metal successfully into very thin sections. Apart from the advantage derived from coke economy, various other benefits not directly ascertainable in money value have resulted, chiefly from cleaner operation.

The question of applying this principle to other sizes and types of cupola, and in particular for other kinds of castings, is now under consideration, and further developments will follow.

In addition, a number of practical experiments have been made on the measurement of air volume and pressure by means of a venturi at the works of the Sheepbridge Coal and Iron Company, Limited, by courtesy of Mr. J. T. Goodwin, M.B.E.

Malleable Cast Iron.

The work carried out on the combined influence of carbon and silicon on white-heart malleable cast iron has been completed, but not yet circulated outside the Malleable Sub-Committee. In the meantime further experiments have been carried out on the influence of size of section on mechanical properties. Current views with regard to malleable iron are likely to be modified as a consequence of the general investigation being made on the structure of cast iron in relation to composition referred to below.

The Strength of Cast Iron in Relation to Size.

Work has been continued on the strength of cast iron in relation to size, some of the results being given in a Paper by the Director to the International Foundry Congress in June. In addition, a number of members have sent test-bars for examination in connection with an inquiry from the Admiralty for assistance in specifying high-quality irons.

In co-operation with Prof. Bulleid, of the University College, Nottingham, the fatigue strength of cast iron is being investigated, and an attempt made to determine the relationship of fatigue to static strength.

The Structure of Cast Iron.

During the year the Senior Metallurgist prepared a report on work of an important and far-reaching character, showing that irons of the same chemical composition may solidify in two entirely different structures and with two differing sets of mechanical properties. In one system the iron contains fine graphite associated generally with ferrite, while in the other system the graphite is normally associated with pearlite, as found in a good engineering iron. In a further report a theory has been evolved to account for the effects observed, and this report was presented to the Iron and Steel Institute. Subsequently it was shown to be possible to take a pig-iron, to melt it so that it solidified according to either of the two systems at will, and to change one type of structure during remelting to the other. These changes were accompanied by anticipated changes in mechanical tests. These results throw an entirely new light on the importance of melting conditions in the production of foundry irons, and attempts are now being made to follow up this matter in the foundry. This development appears likely to have considerable influence upon current views respecting the manufacture of grey irons, chilled irons and malleable irons, and to explain some of the anomalies experienced in the manufacture of grey irons and semi-steels of different mechanical properties, but of similar chemical compositions.

Moulding Sands.

The extensive investigation being conducted at Sheffield by Mr. J. G. A. Skerl, under the supervision of Mr. W. J. Rees, on moulding sands approaches completion. A series of representative sands from beds drawn upon by iron-founders in different parts of the country have been very completely examined, and a report showing their comparative properties is in the press. These sands include examples of red Bunter sands such as Bromsgrove, Kingswinford and Mansfield; yellow sands such as those at Erith and Southampton; and the Scottish rotten-rock sands, Avenuehead, Greenfoot and Loudoun. In addition, a complete report has been prepared relating to the methods of testing adopted in these examinations, which involve chemical analysis, mechanical analysis, or separation into grades according to grain size by elutriation and sieving, refractoriness tests and mechanical-strength tests, including transverse and compression of both dry and green sands. The tests have been carried out with varying moisture contents and varying degrees of ramming, and both before and after milling.

After considerable investigation, two simple tests were chosen by the Sands and Refractories Sub-Committee as suitable for foundry control—the permeability test and the compression-strength test. Arrangements have been made for the permeability tester to be supplied to members at the price of 75s. by the Association's approved supplier in Sheffield. It is hoped that the compression-strength tester will be equally available shortly at a similar price.

The completion of the laboratory work and the development of practical foundry tests brings the work to a point at which it can be applied in members' foundries, and it is hoped that the investigator will be able to spend in future a considerable amount of time in actual foundry visits.

Alloy Cast Irons.

The work on nickel, chromium and aluminium additions to cast iron in which the Association has co-operated in the past is being continued and extended to other additions, particularly vanadium, molybdenum, titanium. This work is being conducted very largely in the ordinary course of other investigations on cast and malleable iron.

Work of Publications Committee.

The general policy pursued by the Association in publications, together with technical propaganda and responsibility for the Information Bureau and Library, is supervised by the Publications Committee, under the chairmanship of Mr. W. B. Parker, F.I.C., assisted by an Editorial Sub-Committee.

Members' Meetings.

During the year one group of private meetings of members was held in ten industrial centres throughout the country, and about 200 members attended in all. The Newcastle meeting passed a resolution asking the Council to arrange these meetings more frequently, but until the Association's staff resources are greater it is with the utmost difficulty that more than two groups of such meetings can be held in the year. Such a group of meetings involves the expenditure of between two and three weeks, including the necessary travelling time, and naturally reduces the amount of time available for visits to members and other necessary work. Of the value and importance of such meetings as a means of communicating results to members and discussing their practical applications there is no doubt.

International Foundry Congress.

The Convention held in London in June by the Institute of British Foundrymen was, by arrangement with the other countries concerned,

an International Foundry Congress combined with a Foundry Exhibition, which was held at the Agricultural Hall. The Association was represented on the Technical Committee, which was deputed to organise a technical exhibit on the lines of one which had been so successful in 1927. Until much more ample funds can be placed at the disposal of the organisers of such an exhibit it is not possible seriously to rival the efforts of the German Ironfounders Association, which assumes responsibility for the German exhibitions, and which has the advantage of a large standing organisation with sixty years' tradition behind it. In spite of the necessarily improvised nature of the arrangements, however, an excellent and representative exhibit of British technical and research work concerned with the founding industries was arranged. A small educational exhibit was also organised by the Association, and it is interesting to note that the American Foundrymen's Association, which is able to run exhibitions on its own responsibility, has decided to make a technical and educational exhibit an integral feature of American foundry exhibitions in future as a result of their seeing the exhibits referred to above.

That part of the technical exhibit in London for which the Association was responsible was transferred at the close of the exhibition to the Science Museum, South Kensington, at the request of the director, Sir Henry Lyons, F.R.S., and has been exhibited there for about four months. During this period the Museum has been visited by some 250,000 people.

Work of Education Committee.

The Education Committee, the formation of which was announced in the last Report, has continued to have the services of Mr. E. R. Briggs, M.Inst.C.E., as chairman. The Committee has considered various means whereby the training of various grades of workers within the industry may be assured, and is at present dealing with detailed educational requirements. The Committee hopes to work in close conjunction with a similar committee appointed by the Institute of British Foundrymen.

Work of Scottish Committee.

During the year the Scottish Committee, of which Mr. G. A. Ure, J.P., is chairman, and Mr. John Cameron, J.P., is vice-chairman, has not found it necessary to hold more than one meeting. The work of the laboratory, however, is actively proceeding, and the appreciation which is felt by the Scottish members for the services of Mr. H. Cowan, superintendent of the Scottish laboratory, may be judged by the fact that his visits to members' works average one per day. The claims on his time are such, in fact, that until a larger staff can be provided, considerable difficulty is experienced in proceeding with the investigation on light castings irons, which is undertaken by Mr. Cowan in addition to the normal work of the laboratory, and conducted by courtesy of Mr. G. A. Ure at the works of Smith & Wellstood, Limited, Bonnybridge. The Council is considerably indebted to the Scottish Committee for the interest taken in the work of the Falkirk laboratory, and in particular to Mr. G. Pate, O.B.E., of the Carron Company, for his interest in cupola tests referred to elsewhere.

Relations with H.M. Government.

Grant Aid.

In the last report it was announced that under certain conditions grant aid would be available to the Association after 1931—that is, the end of the ten-year period, subsequent to which it was originally intended that the Association should be entirely self-supporting. In accordance with the terms of an agreement made with the Advisory Council in 1926, grant was payable at the rate of £1 for each £1 of industrial subscriptions received until July, 1929, at which date the grant was due to fall to 10s. in the £1. It was indicated in the last report that this would have meant a marked fall in the Association's income, and as uncertainty was likely again to arise in 1931, the Council appointed a committee to review the whole situation. This committee decided that an appeal should be made to the Advisory Council to continue the £1 for £1 grant until 1931, when the whole situation should be reconsidered. This appeal was advanced, on both industrial and administrative grounds, in a memorandum prepared by the chairman of Council and director, accompanied by a statement of the results achieved by the Association to date.

The handicaps under which the Association has laboured to date were outlined, including the very serious industrial slump which took place in 1921, the year in which it was founded, and the dislocation consequent on the coal dispute in 1926, when the second five-year period of working commenced. The lack of a single comprehensive manufacturers' association for the industry was also stressed, for this imposes on the Association the necessity for obtaining members by the slow process of individual contact. Many engineering firms, with their own foundries, fail to realise that they are in effect founders, and this is another drawback, founding being regarded in these cases as an auxiliary service. Difficulties in the industry created by the processes of internal reorganisation and economy and by rationalisation have been referred to elsewhere in this report.

It was urged that cast iron is a cheap conglomerate used in a trade where prices are low and profit margins small. Metallurgically, it is highly complex, and hence the industry is not well placed for conducting all the work necessary for its metallurgical elucidation, in spite of the advantages to be derived from it.

This appeal was considered by the Advisory Council and ultimately approved, subject to the datum line of £5,000 per annum being fixed for 1931. This datum was explained in the last Annual Report, and is the income which the Association must obtain from the industry before it can qualify to receive grant. Thus, with a datum line of £5,000, an income of £7,000 per annum would earn grant in respect of the £2,000 received in excess of the £5,000, so that the total income would then reach £9,000 per annum. Under the datum-line scheme the Government is prepared to pay the Association in 1931 and after £1 for £1 on subscription income in excess of £5,000 per annum up to an additional £5,000 per annum, so that the Association, if raising sufficient funds from the industry to qualify for the maximum Government grant available, would have a total income of £15,000 per annum. In the meantime it is hoped that the years 1929-31 will show sufficient development to demonstrate to the industry that membership fees are small in comparison with the benefits received, and that the Association will secure the support of the entire industry on a voluntary basis.

The offer of the Advisory Council was a generous one, and it was unanimously recommended by the Government Grant Committee to the Council for acceptance. The Council took this action on behalf of members, and the cordial thanks of the Association are due to the generous sympathy and encouragement of the Advisory Council during a difficult period of the Association's history.

Finance.

Balance-Sheet and Accounts.

The total income for the year now under review shows a gratifying increase over the previous year, as does the actual subscription income from industrial members. The increase in industrial subscriptions, in fact, is much more marked than in the previous year, and the income shows distinct signs of recovery from the disastrous setback caused by the protracted coal dispute of 1926. This was responsible for a very marked change in the direction of the rising curve of subscription income, and it may be estimated that the dispute, by preventing normal growth, caused an aggregate loss to the Association of £1,000 per annum of subscription income. As a consequence of the increase now recorded it has been possible to increase the expenditure slightly and in addition to wipe out completely the book values of the assets of the Association. The whole of the plant and equipment owned by the Association at its headquarters, offices and laboratories, in several institutions and works where investigations are carried out, and at the Falkirk laboratory, has therefore been depreciated to zero. There are good reasons why a body such as the Association should not create book values for capital expenditure to be depreciated regularly over a period of years. One of the main reasons, which will be more fully referred to below, is the fact that the Association started life without any capital assets. As the Association is expected by the Department of Scientific and Industrial Research to expend its income on the objects for which it was founded (in pursuit of research work), it follows that necessary capital expenditure can only be incurred very gradually out of income. The result is that the Association's resources in plant and equipment are, in fact, grossly inadequate for the work it is required to carry out, and hence it will be necessary for many years to come to expend a certain proportion of income on plant and equipment. This annual charge, therefore, is best expended out of income direct. Furthermore, scientific equipment has an extremely uncertain second-hand value, and a true valuation is not easy to obtain. Including certain costs which have been incurred since the close of the year under review, the total amount expended by the Association on plant and equipment exceeds £4,000. In addition, the assets of the Falkirk laboratory, which were generously presented to the Association when the Foundry Technical Institute merged with the Association in 1926, and which have hitherto been valued nominally in the books at £250, represent a capital investment of over £2,000. The whole of these resources, costing in excess of £6,000, are, of course, the property of members of the Association and are valued in the books at nil.

Capital Expenditure.

As already indicated, the work of the Association is still hampered by lack of adequate and up-to-date equipment. In the interests of members themselves it is desirable that this should be remedied with the least possible delay. The bearing of this on the speed with which results can be furnished to members is also considerable. For example, the Association during the year under review carried out nearly 3,000 mechanical tests on cast iron, of which it was not possible to do more than one-seventh in the Association's laboratory because the necessary equipment was not available. Only since the close of the year under review has it been possible to obtain a testing machine on which tensile, compression and transverse tests can be made. In addition to these facilities it is necessary that the Association should have better equipment for chemical analyses and for the examination of microstructures, and additional machine-tool equipment. Considerable additions will be required in connection with melting and casting, and the necessary pyrometric and other research equipment for the metallurgical study of metals and alloys.

It need scarcely be added that donations from members or gifts in kind which would assist in repairing these deficiencies would be very greatly appreciated by the Council.

Members desiring to assist the Association, however, can do so most effectively by a temporary or permanent increase in their annual subscriptions.

Membership.

The subscribing membership of the Association in all classes is 303, of which the number of ordinary and trade members is 233.

It is interesting to note that while there is a steady increase in the Association's income, the actual number of members does not rise so rapidly; one explanation of this fact is that the size of the average members joining the Association has markedly increased during the last few years. The average subscription has, in fact, increased over 20 per cent. during the past four years. The Council is aware that the subscription basis is very much lower than that of other associations, but believes that a higher-subscription rate would not be a deterrent to membership if the work done by the Association enabled such a rate to be justified on economic grounds.

One of the main obstacles to a more spectacular increase in membership has been the extremely disturbed state of the industry, which has resulted in and been temporarily further upset by the process generally known as rationalisation. Speaking generally, the technical and executive officers of an organisation are among the first to recognise the value of belonging to such a body as the Association, and where a works or a group of works is being subjected to financial reorganisation or grouping, these officers are, as a rule, far too uncertain about the future to suggest so doing. It has been previously emphasised in these reports that the complete lack of statistics relating to the output of the industry makes it very difficult to ascertain its rate of progress. Judging, however, by the output of the raw material of the industry, foundry pig-iron, comparatively little of which is exported, and making suitable modifications for the use of hematite pig and for the use of a certain amount of foundry pig in the steel trade, it is evident that the output in 1928 did not keep pace with the spurt in 1927 which followed the coal dispute. The figures for 1929 so far available show no improvement.

That the industry can support a co-operative technical body is shown by the fact that its products, in the form of castings, and ignoring any further increase in value consequent upon finishing processes or on incorporation into machines, cannot be valued at less than £40,000,000 per annum.

The generous treatment accorded to the Association by H.M. Government, on the advice of the Advisory Council to the Department of Scientific and Industrial Research, makes it incumbent on the industry to support the Association to the utmost, and the desirability of this is emphasised by the number of industries which are adopting, through their manufacturers' associations, a voluntary levy on raw material, the results of which are to be used for the purpose of providing funds for their research association. One industry is seeking legislation to make such a levy a statutory requirement. An association fully representative of the industry which it serves would result in an equitable distribution of responsibility. Members can help the Association very considerably in the following ways:—By seeing that the triennial labour returns include the whole of the labour specified, and by seeing that other founders and all works having a foundry are enrolled as members.

It is also important that other works (having foundries) in the same group or otherwise financially connected become members. It must be emphasised that a member firm is a member in respect of a particular foundry, and that another foundry elsewhere, even under the same financial control, is not a member unless its labour is included in the return and subscription paid in respect of it. Every foundry has the right to nominate a representative to receive reports and correspondence and to serve on the committees and the Council, and suggestions with respect to such service, particularly by men of special knowledge and experience, are always welcomed by the Council. Experience shows that the advantages of membership are derived very largely through the direct contact of the officers of the Association with the foundry, through which applications of new knowledge can be effectively made. Members are urged to encourage their foundry managers to make use of the services provided, and so to establish that direct contact between the Association and the foundry which is essential to its proper functioning as a co-operative research body.

The Association is particularly anxious to interest the large user of castings, because in many cases the developments made by the Association can only be effectively tried in service with the sympathetic co-operation of those who use the irons concerned. Furthermore, the industry as a whole is more accustomed to hearing what users want than to broadcasting improvements it is prepared to supply. The co-operation of users is of great importance, and slight improvements in quality or reductions in cost may mean much more in the aggregate on a material such as cast iron than is the case with special materials used in much smaller quantities. Cast iron represents about two-thirds of the weight output of the engine and machine building industries.

Staff.

During the year the Association lost the services of its investigator on malleable iron, Mr. E. R. Taylor, who has become Lecturer in Metallurgy at the Birmingham Central Technical College.

The Association from time to time requires the services of suitably educated young men to work in the laboratories, without becoming permanent members of the staff. The Council has approved a scheme by which suitable young men may be nominated by members to receive part of their training in the laboratories for a period of two years, subsequently returning to the members' works for further apprenticeship in the foundry or for a technical or executive position.

Conclusion.

Members will see that in addition to its normal services of information, technical advice, and research reports, the Association is now in a position to offer them advice on the following problems, based on research work carried out and to co-operate in the work of applying these developments in the foundry:—

(1) Cupola melting problems, with a view to determining the most rational design, together with the most suitable type and quantity of flux, fuel, and air, for the types of castings required and having regard to temperature of metal, melting economy, and freedom from oxidation.

(2) Moulding-sand problems, with a view to the installation of a simple system of control which will assist on the one hand in reducing defective castings due to the use of old sand, or, on the other hand, to reducing the proportion of new sand necessary to provide a working margin against the risk of defective castings. This problem includes consideration not only of the kind of sand in relation to local supplies, prices, and the kind of castings produced, but its milling treatment, moisture content, and degree of ramming.

(3) Problems arising in connection with demand for high-duty engineering irons, particularly those required to withstand mechanical stress, wear, heat or corrosion.

The Council is confident that the Association will continue increasingly to warrant the support of members. It exists for their benefit, and the Council's chief anxiety is to ascertain their requirements and how the Association can best serve their interests. The Council, therefore, at any time welcomes information relating to difficulties members are called upon to face or developments which are likely to take place in the industry in the future.

The Report is signed by H. B. Weeks, chairman of Council, and J. G. Pearce, director and secretary.

Some Factors in Solidification.

(*Continued from page* 336.)

which, at the time it was carried out, was perhaps more particularly noteworthy as demonstrating the possibilities of utilising the finer mechanisms for timing in conjunction with the use of more highly-sensitised photographic plates. Such reflection will enable one to realise the devastating possibilities of such happenings while metal is in the act of solidifying.

In transferring metal by pouring, one must form a cylinder of liquid metal of variable length. The liquid cylinder is an unstable form and tends, therefore, to subdivide into segments which tend to assume a spherical form—globules or drops. All this will be found analysed and discussed in a chapter on "Liquid Jets," which is contained in Vernon Boys' classical little work on "Soap Bubbles." Inferences from this work enable us to realise more clearly:—(1) The necessity for preserving the continuity of the stream before it reaches the mould, (2) the reason why the total length of the stream should be kept at a minimum, and (3) the desirability of preserving the continuity of the stream after it actually touches the mould and for avoiding, as far as possible, a disturbance or discontinuity which may produce results which are comparable to those of dissolved or occluded gases, although clearly differing radically in origin.

A Rain-Drop Analogy.

Let us consider a simple analogy from the observation that, when large rain-drops fall on a surface of water, large bubbles are seen to form which remain intact for quite an appreciable period of time. This is, of course, due to the fact that in falling on the water the rain-drops carry down air below the surface. This air in rebounding, as it were, and in endeavouring to escape, is trapped by the surface tension of the water, which it distends as a bubble. This bubble, of course, ultimately bursts, but not at once.

If such bubbles form in molten metals by the carrying in of air below the surface, one can readily see the risk which is imminent that they may not be able to break the surface and escape before the metal is solid.

The magnitude of the surface tensions of metals in relation to that of water is such that the tendency towards retention of air carried down in this way becomes a serious matter.

If time had permitted, it would have been interesting to have considered the various devices which have been used for obviating the possibilities for evil which lie in the transfer of metals—devices such as (*a*) sloping the moulds; (*b*) forms of bottom pouring, etc.; (*c*) upward filling; and (*d*) tilting arrangements like the Durville process.

Contracts Open.

Cairo, December 28. — Three Diesel-engine generating sets, two Diesel engines, and pressure plant for water supply, for the Mechanical Department, Ministry of Public Works. The Chief Inspecting Engineer, 41, Tothill Street, S.W.1. (Fee £1 0s. 6d., non-returnable.)

Chapel-en-le-Frith, November 23.—6,100 yds. of 3-in. cast-iron spigot and socket pipes, for the Rural District Council. Brady & Partington, Market Street, Chapel-en-le-Frith. (Fee £5, returnable.)

Dublin, November 18.—Iron and steel stores, for the Great Northern Railway, Ireland. Mr. F. C. Wallace, secretary, Amiens Street Station, Dublin. (Fee 1s., non-returnable.)

Dundee, November 11.—Iron railings, for the Dundee Town Council. Mr. G. Baxter, city engineer, 91, Commercial Street, Dundee.

Manchester, November 12.—Five-ton electrically-driven overhead travelling crane, for the Corporation. The General Manager, Corporation Tramways, 55, Piccadilly, Manchester.

The Real Steel Foundry Problem.*

By G. E. Wells.

During the war it was the writer's good fortune to make the acquaintance of nearly every steel founder in the British Isles, and the experience was a most interesting one. To-day, over ten years after the cessation of hostilities, he still meets many of his competitors, and in response to his query: "Well, how do you find things?" he gets the almost invariable reply "There is a certain amount of work to be had, but only at prices which are simply ruinous." This is the general situation, and it arises principally from the fact that steel foundry capacity is far in excess of orders available, although foreign competition, owing to a lower standard of life and lower wages in foundries abroad, undoubtedly affects the situation to some extent. This state of affairs cannot continue indefinitely, or it will result in creating a situation which right-thinking employers desire to avoid at all costs—the lowering of the standard of life of the British foundry worker.

The general condition of any industry is largely governed by the relation of production costs to selling prices, and it follows therefore that the steel founder has before him two methods by which he may seek to improve the situation. They are (1) to increase his selling prices, and (2) to reduce his production costs.

In regard to No. 1 it is obvious that steel founders have only to put their heads together to the end that price-cutting shall be eliminated. In theory, the thing is amazingly simple, but in practice it bristles with difficulties. First, the artificial elevation of prices would react on the founder by decreasing the volume of work placed, or by driving orders abroad.

Secondly, the British manufacturer is so great an individualist that he often joins an Association of his competitors only for what he can get out of it. The differing views which steel founders hold, many of them purely selfish, would damn the prospects of successful organisation from the start.

Proposition No. 2, therefore, merits careful consideration, and at first sight it would appear that the primary step should be a reduction of wages. However, there are many steel founders, including the writer, who are definitely opposed to this method, and who feel that the real solution lies in an increase of output, individual and collective, with the consequent lowering of the incidence of overhead charges. For British founders to achieve this end collectively, it would appear necessary either to wait patiently until the law of the survival of the fittest can operate of itself, or else to take deliberately such action as will expedite that inevitable result of the present-day cut-throat competition, the elimination of the inefficient foundries.

The author's contention, as will be gathered from the foregoing paragraph, is that British steel foundries are far too numerous, and that, for the country's good, some of them would be better out of the way. This statement will doubtless bring forth a chorus of protests, perhaps from both interested and disinterested persons; but before disagreement is made too emphatic, it would be well to consider calmly the facts of the situation. By the country's good is meant that of the British Isles as a whole, the population of which, to the extent of 80 per cent., depends for existence on imported food. That 80 per cent. must produce and export goods of a value at least equal to the cost of the food they require, or else starve. But before those goods can be exported, they must be sold, and here lies a difficulty. British firms are constantly told that they do not take the steps essential to market their goods. On all sides they are instructed that they must send their principals, their very best men, to meet potential consumers and study their requirements. In addition, they must, it is urged, maintain fully-qualified, works-trained, technical representatives in all countries which can use their products, and must provide the requisite staff and office accommodation. This is a perfectly sound demand, but, it might be asked, does not all this sort of thing cost money, and does not the money so expended become a direct charge on production? Certainly, it does; but the expenditure is justified, and, economically speaking, recovered, as long as it brings in a sufficiently increased volume of work to reduce the incidence of factory standing charges correspondingly.

To-day, a number of founders who have built and extended their works on scientific lines, to give relatively large production, are expending money in the aforesaid manner but their foundries are not fully employed, which means that the expenditure on overseas sales work (essential from the point of view of national economy, since it increases our bulk exports) is not being recovered in lowered production costs. This is entirely due to the activities of the smaller works, which have no such charges to meet, since they do no personal overseas marketing, and which cut prices to obtain a volume of purely home trade which would otherwise swell the output, and so spread over a larger volume of work the standing charges of the larger concerns. This argument is no plea for the restriction of competition. If the smaller foundries were turning out castings equal in quality to those of their bigger rivals, at lower prices, as a result of superior organisational efficiency, the writer would not have a leg to stand on. But the facts are these. The large founder has to maintain: (1) An efficient overseas marketing organisation; (2) efficient research and general laboratories to ensure technical progress and the maintenance of standards, and (3) elaborate testing and inspection departments, to ensure sound work for British and foreign Governments and all other customers.

All these three things are definitely valuable from both the national point of view and that of the individual consumer, but they constitute direct charges on production. The consumer pays more to the steel founder providing these things, but he gets it back in the form of castings and service on which he can depend.

The Problem of the Small Founder.

The small founder, on the other hand, either does not possess these things at all, or he possesses them on the smallest possible scale. By so much less are his production costs burdened. But be it remembered that by so much more are his value to the country and his potential value to his customers reduced. This is not all. The small founder's cut prices are often indicative not of superior but of inferior organisation. They are obtained at the expense of the welfare, comfort and efficiency of his employees. The writer will give examples of this shortly.

It is realised that what has been written will invoke criticism, but the would-be critic should remember that the people of this country must be fed, and that industry must adapt itself to the end that food may be forthcoming. British products, besides being the best procurable, must be produced at an economic figure or they will not sell overseas, and founders must realise this elementary fact. The small foundry cannot fulfil this condition of perfect castings at an economic figure, and, what is worse, in its efforts to do so it reduces the earnings of its workmen to the lowest possible amount. Quite recently a competitor told the writer that his men were working overtime at hourly rates of pay. When asked why he did not reduce the hours worked by paying his men by results, he said his work was too varied to permit of the institution of such a scheme. The statement was ridiculous, because conditions are every bit as difficult in the Edgar Allen Foundry, yet every job there is paid piece-work, and by 5 o'clock each moulder has done a good day's work. In fact, if he were asked to work systematic overtime, his hourly rate of production would eventually decrease, so that he would produce in the longer period no more than he does at present.

A Poor Excuse.

Another founder admitted that he could get economies from the use of moulding machines, but that he had not installed any, as they would produce the work too quickly for the room he had available. This state of affairs cannot continue indefinitely, and the day is fast approaching when employers will have to realise that their first duty is to consider their workmen. The latter have the right to earn to the utmost of their capacity, and they cannot do this in a foundry which is ill equipped and badly organised. Furthermore, an employer's responsibility includes the finding of regular and continuous employment for his men, and allowing them to work in the most valuable and efficient way from the economic point of view.

It is folly to ask a man to do hard work which a machine will accomplish more satisfactorily and in a fraction of the time, besides avoiding the pattern damage caused when the old-fashioned hand-ramming method is persisted in.

For the efficient annealing of castings, batteries of gas-fired furnaces are necessary in place of the wasteful and inefficient coal-fired unit; to produce perfect castings, cleaning plant of the latest type must be installed and a well-equipped machine shop must be maintained. All these things cost money, and are only justified in the case of the foundry with a relatively large output, the type of undertaking whose turnover is large enough to permit of its sending its representatives all over the globe wherever its products are used. It is this type of plant which produces the wherewithal to provide the nation with the food it requires, which maintains the technical progress on which British reputation depends, and which must, in the end, supplant the small and inefficient producer, with his poor organisation, his out-of-date plant, and his desperate struggles to get work at the expense of his workers' comfort.

In writing the foregoing the writer has attempted to argue the necessity for the rationalisation of steel founding, as without the application of this fundamental principle it seems to him impossible for steel foundries to emerge from the slough of despond in which they find themselves to-day.

* From the "Edgar Allen News." The author is a director of Edgar Allen & Company, Limited.

Efficiency of American Blast-furnace Men.—Data from 37 blast-furnace plants in the United States, employing 12,222 men last March, have been compared with similar data from the same number of plants employing 15,329 men in March, 1926. Of the 37 plants 32 were the same individual establishments. In 1926 these 32 establishments operated 114 stacks and employed 13,888 men, an average of 122 men for each stack. In 1929 the same plants operated 108 stacks and employed 11,095 men, or an average of 103 men to each stack. In spite of the smaller number of men to the stack, output of pig-iron for each active stack in March, 1929, was 17,730 tons, compared with 14,900 tons for the corresponding month in 1926. The output figures are those of "The Iron Age," whereas the figures of employment, etc., came from the U.S. Bureau of Labour Statistics. There was a slight increase in the average number of full-time hours in the week's work, which advanced from 59.8 in 1926 to 60.7 in 1929, both comparing with 76.9 in 1913.

Modern Methods of Testing Castings.

At a joint meeting of the Sheffield and District Section of the Institute of British Foundrymen and kindred scientific societies held in the Mappin Hall of Sheffield University on Monday, October 21, Mr. J. S. Glen Primrose, A.R.T.C., C.I.Mech.E., of Manchester, gave an address on "Modern Methods of Testing and Examination and their Influence on the Design of Castings."

Separately-Cast Bars.

Mr. Primrose said: To the man who has not been responsible for the production of the casting, there is always an attractive field of investigation in the examination of foundry failures. Usually, also, before anyone thinks of asking what is the analysis of the metal, the question as to its physical fitness is raised and the usual tensile and bending-test results are inspected. Commonly enough, these results, having been made upon what our American cousins call a "coupon," *i.e.*, a separately-cast test-bar, or at any rate one which comes from a carefully selected part of the casting, show all that can be desired. Then the other methods of investigation are called upon, and test-pieces taken from the fractured face are made and examined, quite often with startlingly different results from those recorded in the test-book. Apart from the fact that the usual method of gripping a test-bar for the tensile test results in its breaking at the weakest part, the structures of the pieces of metal taken from the casting are usually sufficient dissimilar to account for the variations observed. Bending tests usually obey the same laws, but the same limitations do not as a rule apply to both the impact and the shear test, since these test-bars are broken at the predetermined place selected for the purpose, and provided they are properly made, such tests are often more highly informative than the usual tests. The manner of their interpretation and the inference to be drawn from them, especially in regard to their relation with the more commonly specified tests, has been the subject of many bitter controversies, and it must be admitted that the balance of judgment has not yet been arrived at so far as cast iron is concerned. The types of testing machine which may be used for these purposes are very varied, but several of those previously described by the author in Papers to the Institute were illustrated and described.

Several typical examples of failures of castings, both in iron and steel were detailed, and the several methods of examining them recorded briefly by means of test results and photo-micrographs illustrating their internal structural arrangement.

Optical Methods.

One particular example, involving a number of principles, was given in particular detail, and the outcome of the micrographic examination resulted in the application of the optical method of investigating sectional models of castings, using the elastic stress determination advocated by Prof. Coker. In this method use is made of the properties of plane polarised light to detect and determine the intensity of stresses at various parts of the structure. As a result of the investigation, the design of the structure was altered to accommodate the distribution of stress revealed by the photographic record of the model, and the general principle was incorporated in all similar designs by a few simple modifications of the existing patterns.

Another specialised line in which this means of investigation was found useful was in regard to whether certain heavy-duty gear-wheels should have cast-in teeth, solid blanks from which the teeth were to be machined, or a compromise by having rudimentary teeth. As a result of the photo-elastic stress measurements it was found that to meet the changing, yet highly-localised, nature of the stresses, the final method of preparing the casting was preferable, and broken-teeth troubles were reduced to a minimum. These views illustrate the high stress at any point where a sudden change of section occurs, and hence the danger of introducing sharp corners or anything resembling a notch into a structure to be cast. There is very concentrated stress of the point where a load is applied, and where there is no reaction there is no stress. Several examples of this were illustrated by lantern slides.

Electro-Magnetic Systems.

When it is considered that most of our methods of testing involve the destruction of the part or even the whole, it is not to be wondered at that Professor Howe declared we are at the beginning of the art of testing. He was advocating the adoption of a method much in vogue in America and fully described by Dr. Burrows, of the Bureau of Standards, whereby any change in the physical state of a metal, or even any appreciable unsoundness within it, could be made manifest by its reaction to an externally-applied electro-magnetic effect. It is claimed rightly that magnetic analysis can be applied to determine the nature of iron or steel either as a raw material, as a finished product, or even after it has passed through service conditions. For routine work the apparatus required depends on the nature and size of the material to be tested, as well as upon the character of the flaws which are expected. The fundamental fact that a definite relation exists between the magnetic and the mechanical properties, especially of steel, is so well proven, that the successful application of magnetic analysis to commercial testing is practically assured. Difficulties are not excessive, and of course certain preliminary steps are necessary to establish comparative data from which to work and compare the finished product. It is frequently used in the development of a new design.

Another line of electro-magnetic testing is for castings used in electrical construction, where the value of the magnetic permeability is important in keeping down the hysteresis losses. Of course, special castings can now be made which are practically non-magnetic, but in the ordinary castings made of cast iron the energy lost in ergs per cycle may amount to a considerable percentage, especially at high flux densities. In this way it is advisable to compare the results in practice with steel castings, and when the cast iron graph falls away rapidly from the almost straight line for steel, the reason is usually to be found in the design, as found in a specific case quoted, where composition was not at fault.

X-ray Testing.

A recent Paper by Dr. Pullin was a revelation to many founders of the advance which the application of X-ray examination of castings had made. He showed an illustration of the largest tube used at Woolwich, 5 ft. in length and working at over 300,000 volts. Flaws which were only 3 per cent. of the thickness examined could be observed in places up to 3 in. thick. Whilst the photographic records of such radiographs were preferable for later inspection, the visual inspection also had advantages. He said: "The radiography of steel had now reached the stage where it could be applied practically in the factory, yet he felt that the real use of X-rays from the point of view of the foundry would be not so much as a routine inspection, but where it could be used whenever a batch of castings was to be made, then the first of these should be X-rayed immediately, and the foundryman should see the picture and have it explained to him, and if he saw where the faults were and knew what sort of fault they represented, the probability was that while it was fresh in his mind he would be able to modify his technique so that he would get better results. When they did this X-ray examination, the designer should be there also to see what the practical effect on his design was. The immediate examination of castings by X-ray had often enabled a foundryman to correct mistakes and immediately to produce good castings."

At the exhibit of the Woolwich department at the recent International Foundry Exhibition in London, several castings were available for X-rays, and some of the photographs taken of the defective castings showed, not only the ill-effect of chaplets in producing unsoundness, but also the way in which cracks occurred chiefly at the base of brackets, and how transverse and circumferential cracks came in cylinder castings.

DISCUSSION.

Mr. J. R. Hyde said that steel was of complex constitution but more or less uniform. Cast iron was more complex but less uniform, and in consequence the results were very varied, so that any tests that could be applied to verify the value of castings were advisable. Cast iron was cheap, and it was very cheap to break a few to see if they were sound. He also found that machined test-pieces gave more consistent results than pieces tested with the skin on.

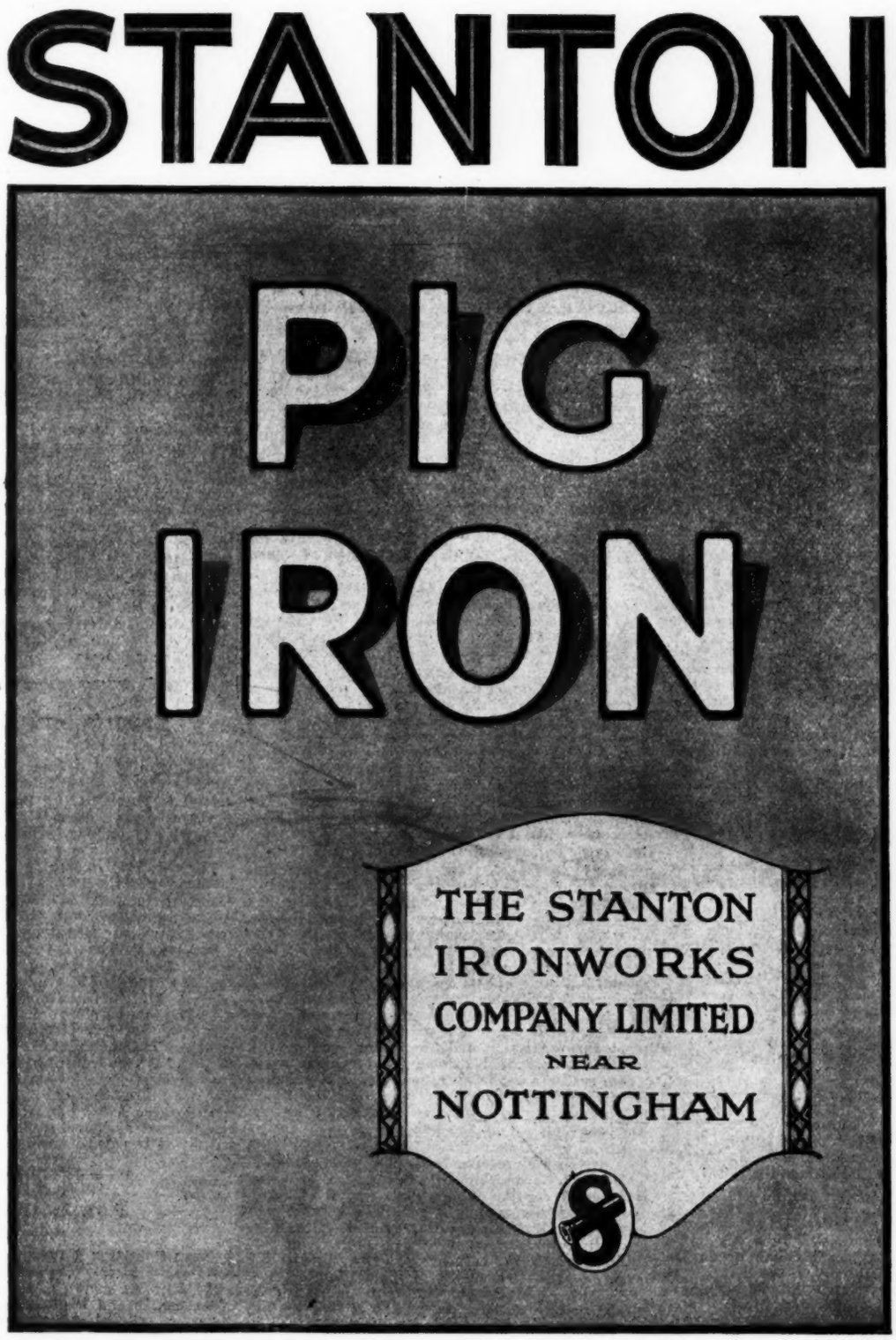
Prof. C. H. Desch said that magnetic methods of testing castings were in extended use in the States, a particular instance being anti-skid chains for motor cars. These were made of case-hardening steel and, normally, one or two were broken up for tests. Now they were run through magnetic search coils and these indicated whether the casing was too thick or too thin without the necessity of breaking any links. With regard to X-ray examination, the technique in this had improved in the past year or two. Usually the whole room, lined with lead, was necessary, and observations were carried out from outside. Recently apparatus had been introduced, consisting of a brass tube with a lead sheath, which could be used in an ordinary room. Many of these were exhibited at Düsseldorf. The material being examined by these was up to three and four inches in thickness. X-ray apparatus, however, used about 300,000 volts and, consequently, could not be used by unskilled labour.

Prof. Lea said that in regard to tensile test, particularly for castings and the like, he did not consider that a test-piece cast on the castings was any guide except to the quality of the metal. He instanced a case where a number of pistons made of aluminium failed at the tensile test and were rejected, but test-pieces cut from the castings, in which care was taken to apply the load axially, gave good results, leading to the acceptance of the castings. Another similar case was provided by a number of aero crank-shafts, in which the same thing occurred.

Mr. J. M. Allan said that in regard to ribs and similar pieces on castings it was important to ensure a uniform rate of cooling as far as possible to avoid unsoundness and internal strains at points where the area of the skin varied.

Mr. Primrose was thanked for his address, on the motion of Mr. T. W. Willis, seconded by Mr. Ambrose Firth.

The directors of Messrs. Pearson & Knowles Coal & Iron Company, Limited, state that during the past year they have given serious consideration to the modernisation of the various industries, particularly those associated with the production of iron and steel. In this connection negotiations have been entered into with neighbouring concerns with a view to an amalgamation of interests. The directors add that they hope to develop a scheme which, in due course, will be presented to debenture holders, shareholders and others interested. A similar reference to a possible amalgamation appears in the annual report of the Partington Steel & Iron Company, Limited, control of which is held by Messrs. Pearson & Knowles.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Trade Talk.

Employment for over 300 steelworkers will be provided by the restarting of additional plant at the Port Talbot Steelworks of Messrs. Baldwins, Limited.

Sir Douglas Fox & Partners, consulting engineers, have been appointed to advise on the scheme for the bridging or tunnelling of the River Humber in the vicinity of Hull.

As the result of an arbitration award, wages in the Saar heavy metal industry have been raised by 2 per cent. A further increase of 1 per cent. will be granted on April 1 next year.

A Paper entitled "Volume Changes during Solidification of Metals and Alloys of Low Melting-Point" was read by Mr. W. E. Goodrich at a meeting of the Faraday Society in London last Thursday.

The London & North-Eastern Railway Company have placed contracts with the North British Locomotive Company, Limited, Springburn, Glasgow, for 14 locomotive boilers, for delivery at the Darlington works.

The Ailsa Shipbuilding Company, Limited, Troon, have received an order from Messrs. William Sloan & Company, Limited, Glasgow, for a cargo steamer of 1,200 tons deadweight, to be used on the Clyde-Bristol Channel service.

Mr. G. W. Roberts, of Rotherham, has been appointed receiver and manager on behalf of the debenture holders of the Midland Iron Company, Limited, Rotherham, and the business of the company is now being carried on under his control.

The Bethlehem Steel Corporation reports a net profit of $11,384,720 for the third quarter of 1929, equivalent to $4.10 on the common stock, after deducting interest, taxes and depreciation, and comparing with $4,272,528 in the corresponding period of 1928.

Messrs. John Brown & Company, Limited, Sheffield, announce that, in addition to a large order for carriage and wagon tyres and axles obtained recently, they have received a further order for 2,500 locomotive tyres for the South African Railways.

Notices have been posted at the Briton Ferry Steelworks and the Albion Steelworks, Briton Ferry, intimating to the men that their contracts will expire at the end of November. The step has been taken owing to depression of the steel trade. About 1,000 employees will be affected.

A message from Johannesburg states that negotiations are proceeding between Manganese Fields, Limited, and an influential Belgian house whose engineer visited the property in the Postmasburg district early this year. It is probable that mining operations will begin at an early date on a large scale.

Messrs. Lithgows, Limited, Port Glasgow, have launched the cargo steamer "Baron Blythswood," which they have built to the order of Messrs. Hugh Hogarth & Sons, Glasgow. The vessel is of 6,200 tons carrying capacity, and is 366 ft. long. The machinery was supplied by Messrs. John G. Kincaid & Company, Limited, Greenock.

Messrs. Ferguson Bros., Port Glasgow, have launched the Royal Research ship "Discovery II," complete with all machinery on board. The vessel is intended for research in Antartic waters, and has been equipped with all the latest appliances for such work. The builders have also supplied the propelling and other machinery.

Two men were killed and three seriously injured by the explosion of a hot-blast stove at the Derwent Works, Workington, of the United Steel Companies, Limited, recently. While testing No. 4 furnace, one of the stoves attached to the furnace ruptured at the dome, releasing the blast and blowing out the top brickwork.

Messrs. Glover, Edwards & Company, 8, Laurence Pountney Hill, London, E.C.4, state that by arrangement with the British Tube Association all purchases from them of Canadian or English tubes will in future be subject to the deferred rebate allowed by the Association, on the same basis as purchases from British tube works.

The Friederich Krupp Company, Essen, announces that, owing to lack of business, it has become necessary to discharge 900 men from various works. The company has decided again not to declare a dividend for the year ended 1928-29. The profits have been earmarked for the necessary completion of rationalisation plans.

The Dominion Bridge Company contemplates the erection of a steelworks at Burnaby, near Vancouver, B.C. Work is likely to be completed on the first unit by the end of March, 1930, and it is probable that a total of $5,000,000 will ultimately be expended on this undertaking. The plant will be equipped with electrically-operated machinery.

The London Power Company, Limited, have placed a contract for the supply and erection of the constructional steelwork for the first section of the new super-power station to be erected at Battersea with Sir William Arrol & Company, Limited, Glasgow. This will, with other contracts already in hand, keep the works of Sir William Arrol fully employed for more than a year.

The 400 men employed in the rolling mills of Messrs. Fred Braby & Company, Limited, Glasgow, have resumed work to permit of their grievance being considered by the sub-committee of the Midland Board, under the agreement governing the wages and conditions of similar grades of workers. The sub-committee of the Midland Board will visit the works shortly and give a decision on the spot.

The works of the Bochum Stahlindustrie, Germany, employing over 1,100 men, are to be closed down some time this month, states Reuter's Cologne correspondent. The assets of the company will be taken over by the Vereingten Stahlwerk concern, but whether the latter, in view of the present state of the iron and steel trade, will be able to provide employment to the discharged men is extremely doubtful.

Messrs. David & William Henderson & Company, Limited, Glasgow, launched the cargo steamer "Dorothy Rose," which they have built for Messrs. Richard Hughes & Company, Limited, Liverpool. She is of single-deck type, 250 ft. in length, 37 ft. in breadth and 18 ft. 6 in. in depth. The propelling machinery consists of triple-expansion engines, with cylinders 19 in., 31 in. and 52 in. dia. by 36-in. stroke.

Messrs. William Hamilton & Company, Limited, Port Glasgow, have launched the twin-screw motor vessel "Athel Princes," which they have built for the United Molasses Company, Limited, London. The vessel is designed for carrying oil and molasses, and is 475 ft. long, 63 ft. 3 in. broad and 35 ft. deep, with a total carrying capacity of 13,000 tons. She is fitted with Diesel engines of the enclosed type, giving 4,000 i.h.p., supplied by Messrs. John G. Kincaid & Company, Limited, Greenock.

The Stanton Ironworks Company, Limited, near Nottingham, have decided to put down a further works for the manufacture of their de Lavaud spun iron pipes. The present works, which have been operating for some years past at an output of about 25 miles of spun iron pipes per week, have proved insufficient for the requirements of the market, and the new works are being laid down for an additional output of 15 miles per week. The pipes in these new works will be made 18 ft. long, from 4 in. dia. upwards, in place of 12 ft. long, for which the present works are designed.

Messrs. Hall, Russell & Company, Limited, Aberdeen, have launched the "Joseph Duhamel," one of the largest trawlers in the world, which they have built for Les Pecheries de Fécamp, France. The vessel has been specially designed for the Newfoundland and Iceland fishing, and is 203 ft. long overall, 31 ft. in breadth and 17 ft. 6 in. in moulded depth. She is fitted with a trawl winch having a capacity for 1,200 fathoms of trawl warp on each barrel. Steam steering gear and steam windlass are fitted, and there has been installed a plant for production and storage of cod-liver oil, together with special searchlights for night work. There is also a special ultra-sound electric sounding machine for depth-recording. The propelling machinery, consisting of triple-expansion steam engines, has been supplied by the builders.

The Union Castle liner "Dunbar Castle" has been launched by Messrs. Harland & Wolff, Limited, from their Govan shipyard, Glasgow. The vessel is intended for the intermediate service to South and East Africa, and is 470 ft. long between perpendiculars, 61 ft. in breadth moulded, 35 ft. 6 in. in depth mounded, and 10,200 tons gross. The propelling machinery consists of two six-cylinder single-acting Diesel engines of the Harland "B. & W." type, arranged for pressure induction. A special feature of the arrangement is that the exhaust gases from the main engine are employed in two directions, *i.e.*, driving turbines which supply air under pressure to each cylinder during the suction stroke, thus increasing considerably the horse-power output, and also for generating steam for ship's use by means of waste-heat boilers. The boilers can also be fired by oil fuel if desired. The electric power is generated from three six-cylinder Diesel sets of the Harland "B. & W." type. The auxiliary machinery is all electrically driven.

Personal.

Mr. Maximilian Mannaberg has resigned his directorship of Messrs. Bolckow, Vaughan & Company, Limited, but it is announced that his services will be available in a consulting capacity.

Mr. Ashley S. Ward has been re-elected chairman and president of the Federated Associations of Scrap Iron, Steel, Metals and Machinery Merchants of Great Britain for the ensuing year.

Mr. H. Spence Thomas, managing director of the Millingriffith Company, Limited, Cardiff, is among the British delegates to the World Engineering Congress in Japan as the representative of the Iron and Steel Institute.

Wills.

Mackay, H. J. S., managing director of the Stirling Boiler Company, Limited, London	£4,881
Mason, Robert, of Chisholm & Mason, York Street, Glasgow, iron and steel merchants	£8,547

Obituary.

The death has occurred, at his residence in Dennistoun, Glasgow, of Mr. Wm. B. Smith, sole partner of Clydesdale Steel & Foundry Company, Limited.

Mr. George Rowe, J.P., managing director of the Upper Forest and Worcester Steel and Tinplate Works, Limited, Morriston, Swansea, died at Brighton on Friday last. Mr. Rowe, who was 75 years of age, joined the Worcester Tinplate Works, Morriston, in 1874. He eventually became manager of both the Worcester and Upper Forest Works. In 1898 he was appointed managing director and secretary of the company. He was a member of the Executive and of the Joint Standing Committee of the South Wales Siemens Steel Association, a member of the Executive of the Welsh Plate and Sheet Manufacturers' Association, and a member of the Conference of the Galvanising and Black Sheet Manufacturers.

Reports and Dividends.

Partington Steel & Iron Company, Limited.—Net profit of £1,676, which is carried forward.

John I. Thornycroft & Company, Limited.—Dividends of 5¼ per cent. on the 7½ per cent. participating preferred ordinary shares, making 9 per cent., and 17½ per cent. on the ordinary shares.

Fairfield Shipbuilding & Engineering Company, Limited.—Profit, £52,192; brought in, £92,034; debenture interest, £23,750; preference dividend, £15,000; dividend of 5 per cent. on the ordinary shares; carried forward, £92,976.

Bolckow, Vaughan & Company, Limited.—Trading profit, £351,989; standing charges on idle plant, £47,316; bank and loan interest, £46,252; debenture interest, £121,491; net profit, £136,929; brought in, £109,307; carried forward, £246,235.

Brown, Bayley's Steel Works, Limited.—Credit balance, including £4,027 brought forward, of £48,912. After deducting the six months' preference dividend paid in April last, it is proposed to pay a further 12 months' dividend on the preference shares, amounting to £25,000, thereby discharging arrears down to January 31, 1928, leaving £11,412 to be carried forward.

New Companies.

James Robertson & Company (Glasgow), Limited, 28, Coxhill Street, Keppochhill, Glasgow.—Capital £12,000 in £1 shares, to carry on business as engineers, smiths and ironfounders.

Baxters (Bolts, Screws and Rivets), Limited, The Parade Works, Birmingham.—Capital £30,000 (10,000 preference and 20,000 ordinary). Directors: H. W. Baxter, A. D. Baxter and G. P. Baxter.

O'Brien Thomas & Company, Limited, 17, Upper Thames Street, London, E.C.—Capital, £53,000 in £1 shares (50,000 7 per cent. cumulative preference). Ironfounders, ironmasters, etc. Directors: H. W. O'Brien, T. O'Brien, D. P. O'Brien, E. H. Howard, and A. P. Harrop.

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MONOLITHIC LININGS

Mr. H. C. ELLIOTT, in a recent paper on this subject reprinted in "The Refractories Journal" for August (page 363) says :—

"A monolithic lining is designed to take the place of firebrick.

"Good firebricks are obtainable, but a firebrick lining is dependent entirely on the joints and no matter how carefully the bricks are laid, the joints usually break down before the bricks, and this results ultimately in breaking down the bricks."

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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH. — This week's Cleveland iron market has disclosed few developments in regard to the general position of the local trade, chief interest being concentrated on the probable effects of forthcoming political movements threatening a disturbance of the mining industry. This question, as previously reported, is one of vital importance to Tees-side interests, the present position of the Cleveland iron markets being largely attributable, as concerns the existing high prices ruling, to the excessive costs of fuel in furnace production, which have reached the highest level touched for some years past, and at present there is no prospect whatever of any reduction. On the contrary, works costs are still rising steadily, and inevitably that involves the perpetuation of the present high price of pig-iron, if not a further advance. Meanwhile, Middlesbrough has almost wholly lost its export trade in foundry pig-iron. Only hematite is being shipped abroad in any quantity, and parcels of cheap basic and foundry grades are being sold on Tees-side at prices slightly less than those quoted for local iron. Makers' fixed prices are:—No. 1 Cleveland foundry iron, 75s.; No. 3 Cleveland G.M.B., 72s. 6d.; No. 4 foundry iron, 71s. 6d.; No. 4 forge iron, 71s. per ton.

Some slight improvement can be noted in the East-Coast hematite market this week, and a rather firmer tone prevails with regard to makers' prices, which for some time past have been below the cost of production. Consequently, makers have now determined to exact a minimum of 78s. both for prompt and forward deliveries, and, as they have made heavy sales and have little more for disposal this year, they hope to be able to narrow the gap between selling prices and works costs still further. On the North-West Coast, Bessemer mixed numbers are quoted at 77s. per ton at works.

LANCASHIRE.—Consumptive demand for foundry pig-iron in this area continues fairly well maintained, but new business has slowed down to some extent, due to forward contracts made earlier in the season, for which deliveries are going forward in satisfactory volume. The price position is undoubtedly strong, Midland varieties—Staffordshire and Derbyshire—being on offer at 77s. per ton. There has been only a quiet demand for Scottish brands of pig-iron at 92s. 6d. to 93s. 6d., all delivered locally.

THE MIDLANDS.—The demand for pig-iron for Black Country foundries is fully maintained so far, although buying of late has not been on a heavy scale, many consumers having already completed contracts over the year's end. Prices remain firm, with No. 3 Northants quoted at 75s., No. 3 Derbyshire at 78s. 6d., No. 3 North Staffordshire at 79s. 6d., and Scotch brands at 95s., all per ton, delivered local stations.

SCOTLAND.—The market for Scottish pig-iron continues to present a dull appearance. While a few founders are fairly busy, the bulk of consumers complain of want of orders. Consequently, the demand for pig-iron is not extensive, and the few furnaces making foundry iron are easily able to cope with the demand. Prices are unchanged at 76s. per ton for No. 3 quality foundry iron.

Finished Iron.

At Birmingham the only satisfactory feature about the bar-iron market is in connection with Staffordshire marked bars, which are quoted at £12 10s. at works. The mills making this class of bar are fairly well engaged, and there is a prospect of still better times to come. The business emanating from this and other areas for crown iron is very disappointing indeed, and none of the mills is working at full capacity, some of them operating only intermittently. The current quotation for Belgian nut and bolt iron is about £6 5s. delivered this district, and for home manufactured £9 per ton. While this position obtains there cannot be much business offering for the home product.

Steel.

The placing of a succession of steel orders in Sheffield and the neighbourhood lately has had a good effect on the steel market, and a greater volume of business is being transacted, although there is no doubt about the expansion of Continental competition in basic billets. Some improvement in the demand for acid billets is also a satisfactory feature, but it is impossible to say definitely whether this marks a revival after the prolonged period of depression. The market for wire rods is good. Prices:—Basic billets, soft, £7; semi-hard, £7 12s. 6d.; medium, £8 2s. 6d.; hard, £9 2s. 6d. to £9 12s. 6d.; Siemens acid, £9 10s.; wire rods, soft basic, £8 10s.; medium, £9 15s. to £10; hard, £10 10s. to £11; acid, £12 5s. to £12 10s.; steel hoops, £9 15s. to £10. In the tinplate market quotations may be put generally at 18s. 10½d. to 19s. basis for coke tinplates, net cash, f.o.b. Wales.

Scrap.

Reports from the principal centres of distribution of foundry scrap material disclose only an indifferent demand, but on Tees-side there is still a steady trade in heavy cast iron, buyers being prepared to pay up to 68s. 6d. for good machinery quality in handy pieces, while ordinary foundry grades realise 66s. per ton. In Scotland, the market for cast-iron scrap is rather weak. Prices have not fallen very much, but the closing of so many consumers' works has inconvenienced merchants who had contracted for regular deliveries, and they now find it very difficult to obtain new outlets. The position so far as all classes of cast-iron scrap is concerned is not much better, as the requirements of the foundries are still limited, and there is no inducement with present prices to sell ahead. Current prices are as follow:—Machinery cast-iron scrap, 70s.; and heavy ordinary cast iron, suitable for foundries, 65s.; cast-iron chairs, 67s. 6d.; and cast-iron borings, 55s. The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—Values of warrant copper continue the weakened tendency reported recently, and so far there appears little occasion for an optimistic view of the general position of this section of the base metal markets. It is generally recognised that production of the metal is still in excess of consumption, and the actual productive capacity, of course, far exceeds the demand. Copper Exporters, Inc., however, are not likely to lose their control of the situation, as it does not seem that there can be any large increase in production by companies outside the control.

Closing quotations are:—

Cash.—Thursday, £71 to £71 2s. 6d.; Friday, £71 8s. 9d. to £71 11s. 3d.; Monday, £70 7s. 6d. to £70 8s. 9d.; Tuesday, £69 7s. 6d. to £69 10s.; Wednesday, £66 2s. 6d. to £66 7s. 6d.

Three Months.—Thursday, £70 8s. 9d. to £70 10s.; Friday, £70 17s. 6d. to £70 18s. 9d.; Monday, £70 6s. 3d. to £70 7s. 6d.; Tuesday, £69 7s. 6d. to £69 8s. 9d.; Wednesday, £66 2s. 6d. to £66 5s.

Tin.—After some days of weakening quotations towards the week-end tin prices showed some improvement, only to register a further fall. The statistical position is not regarded as favourable to higher values, and it is known that production still considerably outstrips the demand. Moreover, conditions in America are very unsettled, and it would seem that any sharp rise in prices which may take place can only be due to speculative activities. As regards the demand on this side, it is reported that an improvement has taken place.

Official closing prices:—

Cash.—Thursday, £189 to £189 5s.; Friday, £185 10s. to £185 15s.; Monday, £181 15s. to £182; Tuesday, £178 10s. to £178 15s.; Wednesday, £176 5s. to £176 10s.

Three Months.—Thursday, £192 to £192 5s.; Friday, £188 10s. to £188 15s.; Monday, £185 to £185 5s.; Tuesday, £181 15s. to £182; Wednesday, £179 15s. to £180.

Spelter.—This market has shared in the general weakness, and prices show a substantial decline on the past week. The galvanising industry in this country is unfortunately passing through a very depressed period, and the demand from this quarter is at present comparatively small.

Daily quotations are:—

Ordinary.—Thursday, £22 1s. 3d.; Friday, £22; Monday, £21 17s. 6d.; Tuesday, £21 13s. 9d.; Wednesday, £21 5s.

Lead.—The market for soft foreign pig remains steady, and the slight drop in prices may be regarded as a movement in sympathy with the other base metal markets. Consumption remains good, and the statistical position is favourable on the whole.

The week's prices have been:—

Soft Foreign (Prompt).—Thursday, £22 12s. 6d.; Friday, £22 10s.; Monday, £22 5s.; Tuesday, £22 2s. 6d.; Wednesday, £22 1s. 3d.

Students' Corner.

Q.—How can liquid shrinkage be explained or demonstrated?

A.—If three 12-in. cubes be poured open-sand, such behaviour can be verified, as the liquid shrinkage can be roughly measured. One cube is poured with a No. 1 grade of iron, which is dead soft. It contains a high total carbon, 4 per cent., the maximum amount of graphite carbon, the minimum amount of combined carbon, a high silicon 3 per cent., and a low sulphur 0·03 per cent. Another cube is poured with a No. 4 grade of iron, which contains a lower total carbon, 3·5 per cent. Part of this is combined—a medium silicon content 2 per cent., and a rather higher sulphur 0·06 per cent.; this metal is of medium hardness. The third cube is poured with a white iron, very hard, brittle and unmachinable. It contains a low total carbon, 2·5 per cent., with a maximum of combined carbon and a minimum of graphitic carbon, and a high sulphur content, over 0·10 per cent.

With the first cube, a No. 1 grade, the liquid shrinkage level is rather lower than the liquid line on the second cube, which is a No. 4 grade. Also, underneath the shrinkage of the first cube some spongy places exist, which is common with that grade of iron. This sponginess is unobservable in the second cube.

The shrinkage line in the third cube, *i.e.*, white iron, is lower than either of the other two, and there is an entire absence of any sponginess, porosity or graphitic carbon. So the conclusions reached are:—From a No. 1 grade to a No. 4 grade the liquid contraction decreases, and from a No. 4 grade to a white iron the liquid contraction increases, and from a No. 1 grade to a white iron it becomes denser and harder. The final conclusion is that a No. 4 grade exhibits the least liquid contraction, and requires the least feeding.

Q.—What occurs as the freezing of cast iron takes place?

A.—An ordinary foundry iron was poured into a 12-in. cube at a medium temperature—say about 1,400 deg. C. With such a casting solidification is fairly easy to follow; the casting is about 4 cwt., enclosed within six walls of sand. As heat is evolved, freezing generally commences at the bottom and sides and proceeds towards the top. As soon as molten iron rests on, or against a wall of sand, transmission of heat is increased, and continues until solidification is complete. If the walls of sand are closer together than a 12-in. cube, freezing will be more rapid. If the walls of sand are further apart the freezing will be slower.

The top wall of sand which covers the casting will be the last to transmit heat, which is due to the gradual sinking away of the metal from it as liquid contraction is taking place; consequently, the whole top surface of the cube is not in close contact with the sand which forms the top part.

(To be continued.)

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MIDDLESBROUGH ON TEES.

TELEGRAMS:
REFINERY MIDDLESBROUGH.

ALSO MAKERS OF
HIGH CLASS REFINED PIG IRON
IN SMALL PIGS, FOR ALL KINDS OF
MALLEABLE CASTINGS

TELEPHONE:
MIDDLESBROUGH 4265.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	66	2	6
Three months	66	2	6
Electrolytic	82	0	0
Tough	74	5	0
Best selected	74	15	0
Sheets	110	0	0
India	92	0	0
Wire bars	84	0	0
Do. Nov.	84	0	0
Do. Dec.	84	0	0
Ingot bars	—		
H.C. wire rods	86	0	0
Off. av. cash, October	72	17	2 1/32
Do., 3 mths., October	73	4	1 3/16
Do., Sttlmnt., October	72	17	6
Do., Electro, October	84	5	2 1/4
Do., B.S., October	77	15	10
Do., wire bars, October	84	10	10 11/32
Aver.spot price,copper,Oct.	72	17	2 1/32
Solid drawn tubes			15d.
Brazed tubes			15d.
Wire			11 1/4d.

BRASS.

Solid drawn tubes	12 1/2d.
Brazed tubes	14 1/2d.
Rods, drawn	12 1/2d.
Rods, extd. or rlld.	8d.
Sheets to 10 w.g.	11 1/2d.
Wire	10 1/2d.
Rolled metal	10 1/2d.
Yellow metal rods	8d.
Do. 4 × 4 Squares	8 1/2d.
Do. 4 × 3 Sheets	9d.

TIN.

	£	s.	d.
Standard cash	176	5	0
Three months	179	15	0
English	177	0	0
Bars	180	15	0
Straits	182	10	0
Australian	181	0	0
Eastern	187	0	0
Banca	189	10	0
Off. av. cash, October	190	17	7 3/25
Do., 3 mths, October	194	17	3 9/25
Do., Sttlmt., October	190	17	7 3/25
Aver. spot, October	190	17	7 3/25

SPELTER.

	£	s.	d.
Ordinary	21	5	0
Remelted	20	0	0
Hard	19	0	0
Electro 99.9	23	15	0
English	22	2	6
India	20	0	0
Zinc dust (Nom.)	32	10	0
Zinc ashes	7	0	0
Off. aver., October	23	2	6 1/25
Aver., spot, October	22	18	6 9/25

LEAD.

	£	s.	d.
Soft foreign ppt.	22	1	3
English	23	15	0
Off. average, October	23	4	9 9/25
Average spot, October	23	4	6 3/25

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	30	10	0
Do. V.M. ex-whf.	29	5	0
Rods	34	0	0
Boiler plates	27	0	0
Battery plates	28	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	50	0	0
Chinese	30	15	0
Crude	20	15	0

QUICKSILVER.

	£	s.	d.
Quicksilver	22	7	6

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
45%	7	17	6
25/50%	11	10	0
75%	19	0	0
Ferro-vanadium—			
35/50%	12/10 lb. Va.		
Ferro-molybdenum—			
70/75% c. free	4/2 lb. Mo.		
Ferro-titanium—			
23/25% carbonless	1/2 lb.		
Ferro-phosphorus, 20/25%	£16	0	0
Ferro-tungsten—			
80/85%, c. fr.	3/3 1/2 lb.		
Tungsten metal powder—			
98/99%	3/6 1/2 lb.		
Ferro-chrome—			
2/4% car.	£30	10	0
4/6% car.	£23	2	6
6/8% car.	£22	0	0
8/10% car.	£21	17	6
Ferro-chrome—			
Max. 2% car.	£33	5	0
Max. 1% car.	£38	0	0
Max. 0.70% car.	£39	15	0
70%, carbonless	1/- lb.		
Nickel—99% cubes, or pellets	£175	0	0
Ferro-cobalt	9/6 lb.		
Aluminium 98/99%	£95	0	0
Metallic chromium—			
96/98%	2/6 lb.		
Ferro-manganese (net)—			
76/80% loose	£13	10	0
76/80% packed	£14	10	0
76/80%, export	£14	0	0
Metallic manganese—			
94/96%, carbonless	1/6 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0	2	0
Finished bars, 18% tungsten	£0	2	9

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/4 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 3/16 in.	1/- lb.
Flats, 1/4 in. × 1/4 in. to under 1 in. × 3/8 in.	3d. lb.
Do., under 1/4 in. × 1/4 in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Heavy steel	3	13	6	to 3	15	0
Bundled steel and shrngs.	3	11	0	to 3	14	0
Mixed iron and steel	3	7	6	to 3	9	0
Heavy cast iron	2	18	6	to 3	0	0
Good machinery for foundries	3	0	0	to 3	5	0
Cleveland—						
Heavy steel			3	5	0	
Steel turnings			2	17	6	
Cast-iron borings			2	13	6	
Heavy forge			3	15	0	
W.I. piling scrap			3	10	0	
Cast-iron scrap	3	6	0	to 3	8	6
Lancashire—						
Cast-iron scrap	3	2	6	to 3	10	0
Heavy wrought				4	0	0
Steel turnings				2	17	6
Scotland—						
Heavy steel			3	12	6	
Cast-iron borings			2	15	0	
Wrought-iron piling			3	18	6	
Heavy machinery			3	10	0	

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	65	0	0
Brass	44	0	0
Lead (less usual draft)	20	0	0
Tea lead	17	10	0
Zinc	15	10	0
New aluminium cuttings	64	0	0
Braziery copper	58	0	0
Gunmetal	58	0	0
Hollow pewter	140	0	0
Shaped black pewter	100	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	75/-
Foundry No. 3	72/6
Foundry No. 4	71/6
Forge No. 4	71/-
Hematite No. 1	78/6
Hematite M/Nos.	78/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	86/-
,, d/d Birm.	93/6
Midlands—	
Staffs. common*	—
,, No. 4 forge*	75/6
,, No. 3 fdry.*	79/6
Shrops. basic	—
,, Cold blast, ord.	—
,, ,, roll iron	—
Northants forge*	71/-
,, fdry. No. 3*	75/-
Derbyshire forge*	74/6
,, fdry. No. 3*	78/6
,, basic*	—

*d/d Black Country dist.

Scotland—	
Foundry No. 1	78/6
,, No. 3	76/-
Hem. M/Nos.	80/-
Sheffield (d/d district)—	
Derby forge	69/9
,, fdry. No. 3	73/6
Lincs. forge.	73/-
,, fdry No. 3	77/-
E.C. hematite	88/6
W.C. hematite	89/6
Lincs. (at furnaces)—	
Forge No. 4	73/-
Foundry No. 3	75/-
Basic	74/-
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	77/-
Northants foundry No. 3	—
Dalzell, No. 3 (special)	105/- to 107/6
Summerlee, No. 3	93/-
Glengarnock, No. 3	—
Gartsherrie, No. 3	93/-
Monkland, No. 3	93/-
Shotts, No. 3	93/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron ; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.) nom.				10	15	0
Nut and bolt iron	9	0	0	to 9	5	0
Hoops				11	0	0
Marked bars (Staffs) f.o.t.				12	10	0
Gas strip				11	0	0
Bolts and nuts, 3/4 in. × 4 in.				15	5	0
Steel—						
Ship plates	8	12	6	to 8	17	6
Boiler plts.	9	12	6	to 10	10	0
Chequer plts.				10	12	6
Angles				8	2	6
Tees				9	2	6
Joists				8	2	6
Rounds and squares, 3 in. to 5 1/2 in.				9	2	6
Rounds under 3 in. to 3/8 in. (Untested)				8	2	6
				and upwards		
Flats—8 in. wide and over				8	7	6
,, under 8 in. and over 5 in.				8	12	6
Rails, heavy	8	10	0	to 9	0	0
Fishplates				12	10	0
Hoops (Staffs)				9	15	0
Black sheets, 24 g.				10	5	0
Galv.cor.shts., 24g.	12	17	6	to 3	2	6
Galv. fencing wire 8g. plain				12	0	0
Billets, soft	6	5	0	to 6	15	0
Billets, hard	7	10	0	to 8	0	0
Sheet bars				6	5	0
Tin bars				6	5	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1/4
Sheet to 10 w.g.	1/5
Wire	1/6 1/2
Rods	1/5
Tubes	1/9 1/2
Castings	1/4

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	10d. to 1/4
Rolled—	
To 9 in. wide	1/4 to 1/10
To 12 in. wide	1/4 1/2 to 1/10 1/2
To 15 in. wide	1/4 1/2 to 1/10 1/2
To 18 in. wide	1/5 to 1/11
To 21 in. wide	1/5 1/2 to 1/11 1/2
To 25 in. wide	1/6 to 2/-
Ingots for spoons and forks	10d. to 1/6 1/2
Ingots rolled to spoon size	1/1 to 1/9 1/2
Wire round—	
3/0 to 10 G.	1/7 1/2 to 2/2 1/2

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic	20.26
Bessemer	20.76
Malleable	20.76
Grey forge	19.76
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bessemer billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	35.00
Wire rods	40.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.90
Tank plates	1.95
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.75
Sheets, galv., No. 24	3.50
Sheets, blue an'l'd, No. 13	2.35
Wire nails	2.40
Plain wire	2.40
Barbed wire, galv.	3.05
Tinplates, 100-lb. box	$5.35

COKE (at ovens).

Welsh foundry	27/6
,, furnace	22/6 to 24/-
Durham and Northumberland—	
,, foundry	22/6
,, furnace	21/3
Midlands, foundry	—
,, furnace	21/6 and up

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 box	18/9
,,	28×20 ,,	37/6
,,	20×10 ,,	27/6
,,	18 3/4×14 ,,	19/6
C.W.	20×14 ,,	15/6
,,	28×20 ,,	34/-
,,	20×10 ,,	22/7 1/2
,,	18 3/4×14 ,,	16/-
Terneplates	28×20	33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0	to	£7	10 0
Bars, hammered, basis	£17	10	0	to	£18	10 0
Bars and nail-rods, rolled, basis	£15	15	0	to	£16	15 0
Blooms	£10	0	0	to	£12	0 0
Keg steel	£32	0	0	to	£33	0 0
Faggot steel	£20	0	0	to	£24	0 0
Bars and rods dead soft, steel	£11	0	0	to	£14	0 0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.

Over ½ in. up to 6 in.

	Tubes.	*Fittings.*
Gas	65%	47½%
Water	61¼%	42½%
Steam	57½%	37½%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Oct.	31 ..	71	0	0	inc.	13/9
Nov.	1 ..	71	8	9	„	8/9
„	4 ..	70	7	6	dec.	21/3
„	5 ..	69	7	6	„	20/–
„	6 ..	66	2	6	„	65/–

Electrolytic Copper.

		£	s.	d.			
Oct.	31 ..	83	10	0	No	change	
Nov.	1 ..	83	10	0	„	„	
„	4 ..	83	10	0	„	„	
„	5 ..	82	0	0	dec.	30/–	
„	6 ..	82	0	0	No	change	

Standard Tin (cash).

		£	s.	d.		
Oct.	31 ..	189	0	0	inc.	95/–
Nov.	1 ..	185	10	0	dec.	70/–
„	4 ..	181	15	0	„	75/–
„	5 ..	178	10	0	„	65/–
„	6 ..	176	5	0	„	5/–

Tin (English ingots).

		£	s.	d.			
Oct.	31 ..	189	0	0	inc.	80/–	
Nov.	1 ..	185	10	0	dec.	70/–	
„	4 ..	182	0	0	„	70/–	
„	5 ..	178	15	0	„	65/–	
„	6 ..	177	0	0	„	35/–	

Zinc Sheets (English).

		£	s.	d.			
Oct.	31 ..	31	10	0	No	change	
Nov.	1 ..	31	10	0	„	„	
„	4 ..	31	10	0	„	„	
„	5 ..	30	10	0	dec.	20/–	
„	6 ..	30	10	0	No	change	

Spelter (ordinary).

		£	s.	d.			
Oct.	31 ..	22	1	3	No	change	
Nov.	1 ..	22	0	0	dec.	1/3	
„	4 ..	21	17	6	„	2/6	
„	5 ..	21	13	9	„	3/9	
„	6 ..	21	5	0	„	8/9	

Lead (English).

		£	s.	d.			
Oct.	31 ..	24	0	0	No	change	
Nov.	1 ..	24	0	0	„	„	
„	4 ..	24	0	0	„	„	
„	5 ..	23	15	0	dec.	5/–	
„	6 ..	23	15	0	No	change	

AVERAGE MONTHLY PRICES OF RUBIO ORE (MIDDLESBROUGH).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1890	0 15 4	0 15 4	0 15 4	0 15 4	0 15 4	0 15 4	0 15 4	0 14 3	0 14 3	0 15 7½	0 15 7½	0 15 7½	0 15 2¾
1891	0 15 7½	0 14 2½	0 14 2½	0 14 2½	0 13 6¾	0 13 6	0 13 3¾	0 13 0	0 12 11	0 13 0	0 13 7	0 13 1	0 14 9½
1892	0 13 1	0 12 9	0 12 9	0 12 9	0 12 9	0 11 10½	0 12 1	0 12 1	0 12 2	0 12 0	0 12 0	0 11 11	0 12 4½
1893	0 11 11	0 11 5½	0 11 10	0 11 10	0 12 1½	0 12 3	0 12 1½	0 12 3	0 12 1	0 12 4	0 12 4½	0 12 6	0 12 0½
1894	0 12 6	0 12 6	0 12 7½	0 12 1½	0 12 4	0 12 1	0 12 0	0 12 0½	0 11 10½	0 12 2	0 12 0	0 12 0	0 12 1¼
1895	0 12 0	0 12 0	0 11 10	0 12 0	0 12 0	0 12 3	0 12 3	0 12 4	0 12 4	0 12 6	0 12 7	0 12 6	0 12 2½
1896	0 12 6	0 12 6	0 12 9	0 12 9	0 12 9	0 12 7	0 12 9	0 12 9	0 12 9	0 13 6	0 15 0	0 14 9	0 13 1
1897	0 15 3	0 15 6	0 15 3	0 15 0	0 14 0	0 14 3	0 14 3	0 14 0	0 14 0	0 15 0	0 14 3	0 15 3	0 14 8
1898	0 15 0	0 14 4	0 14 9	0 14 6	0 15 0	0 15 0	0 14 0	0 14 0	0 14 0	0 14 9	0 15 0	0 14 9	0 14 7
1899	0 15 0	0 15 3	0 15 6	0 15 6	0 15 9	0 16 0	0 17 6	0 18 0	0 17 9	0 18 0	0 19 0	1 0 0	0 16 11½
1900	1 1 0	1 0 6	1 1 0	1 0 9	1 1 0	1 1 0	1 1 3	1 1 6	1 1 3	1 1 3	1 0 0	0 18 0	1 0 8½
1901	0 17 6	0 16 0	0 15 0	0 14 6	0 15 6	0 15 9	0 14 9	0 15 3	0 15 9	0 15 9	0 15 9	0 15 9	0 15 7¾
1902	0 15 6	0 15 0	0 16 0	0 16 0	0 15 6	0 15 3	0 15 6	0 16 0	0 16 0	0 16 0	0 15 9	0 15 6	0 15 8¼
1903	0 15 6	0 16 0	0 16 6	0 16 3	0 16 3	0 16 10	0 15 9	0 15 6	0 15 6	0 14 9	0 14 9	0 15 1	0 15 8
1904	0 14 9	0 15 3	0 15 1	0 15 4	0 15 3	0 15 0	0 14 5	0 14 6	0 14 6	0 14 6	0 14 6	0 14 7	0 14 9½
1905	0 15 3	0 15 6	0 15 0	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 16 6	0 18 6	0 18 9	0 18 9	0 16 3½
1906	1 0 0	1 1 6	1 0 0	1 0 0	0 19 6	1 0 0	0 19 6	0 19 4	1 0 6	1 1 6	1 1 9	1 3 6	1 0 7
1907	1 3 6	1 2 6	1 2 6	1 2 0	1 1 6	1 2 3	1 2 3	1 2 0	1 1 0	0 19 0	0 18 9	0 17 6	1 1 2½
1908	0 16 6	0 15 0	0 15 6	0 15 6	0 15 3	0 15 0	0 15 0	0 14 9	0 15 0	0 16 0	0 16 0	0 16 0	0 15 5¾
1909	0 15 9	0 16 3	0 16 0	0 16 0	0 16 3	0 16 6	0 16 0	0 16 0	0 17 0	0 17 0	0 17 6	0 17 6	0 16 6
1910	1 0 4	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 3	1 0 3	1 0 6¾	1 1 3	1 1 5	1 0 9¾
1911	1 2 2½	1 2 6	1 2 6	1 1 11½	1 0 11½	0 19 6	0 19 0	0 19 0	0 19 1¾	0 19 6	1 0 0½	1 1 6½	1 0 7¾
1912	1 2 3	1 2 6	1 2 6	1 1 1½	1 1 6	1 1 6	1 1 6	1 2 3	1 2 6	1 3 0	1 3 0	1 2 11	1 2 2½
1913	1 2 9	1 2 2	1 1 7½	1 1 6	1 0 8½	1 0 0	1 0 0	1 0 0	0 19 10½	0 19 1½	0 19 0	0 19 0	1 0 5¾
1914	0 18 7½	0 18 0	0 18 0	0 17 9	0 17 6	0 17 6	0 17 1½	0 19 7½	0 18 11½	0 17 10½	0 18 7½	1 1 0½	0 18 5½
1915	1 7 7½	1 8 6	1 9 3	1 10 2½	1 8 6	1 6 4	1 5 10½	1 6 0	1 6 10½	1 10 8½	1 13 0	1 17 10	1 9 1½
1916	1 18 6	2 0 1½	2 2 6½	2 0 6½	1 15 0	1 16 3	1 18 0	1 18 0	1 18 0	—	—	—	—
1917	} Price Fixed												
1918													
1919	—	—	—	—	2 5 7½	2 14 4½	2 16 4½	2 14 0	2 13 4½	2 13 0	2 12 7½	2 11 9	—
1920	2 17 0	3 7 9	2 15 6	3 6 7	3 0 0	2 15 0	2 14 0	2 9 9	2 7 6	2 11 0	2 12 3	2 10 0	2 15 0
1921	2 1 0	2 0 1½	1 18 3	1 17 6	1 17 6	1 17	1 17 6	1 5 0	1 8 9½	1 7 9	1 7 0	1 7 0	1 13 8¾
1922	1 6 7½	1 5 10½	1 6 11	1 7 0	1 7 0	1 7 0	1 5 3	1 4 9¾	1 4 2¼	1 3 3¾	1 2 6	1 2 3	1 5 2½
1923	1 2 9¾	1 4 6¾	1 5 2	1 4 8¼	1 4 6	1 4 0	1 3 6	1 3 0	1 3 0	1 3 0	1 3 2¼	1 4 9	1 3 10½
1924	1 4 2½	1 4 0	1 4 0	1 3 7½	1 3 8½	1 3 6	1 2 11	1 2 6	1 2 1½	1 1 7½	1 2 3	1 2 6	1 3 1
1925	1 2 6	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 6	1 0 6	1 0 0	1 0 0	1 0 0	1 0 3	1 0 10½	1 1 1½
1926	1 1 1½	1 1 6	1 1 6	1 1 3½	1 1 3	1 1 5½	1 1 6	1 1 6*	1 1 0*	1 1 6*	1 1 6*	*	1 1 4½
1927	1 2 1½	1 2 3	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 7½	1 1 0	1 1 0	1 1 0	1 1 0	1 1 0	1 1 7½
1928	1 1 0	1 1 1½	1 1 11	1 2 4½	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 2½
1929	1 2 6	1 2 6½	1 2 11½	1 3 0	1 3 0	1 3 2½	1 4 0	1 4 8½	1 4 7½	1 4 6	—	—	—

* Prices nominal.

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

PIG IRON

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

19, ST. VINCENT PLACE, GLASGOW.

ZETLAND ROAD, MIDDLESBROUGH.

SITUATIONS VACANT AND WANTED.

FOREMAN PATTERN-MAKER, 5 years partner in pattern-making firm; good organiser and estimator; general engineering experience; age 30 years.—Box 374, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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